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THE

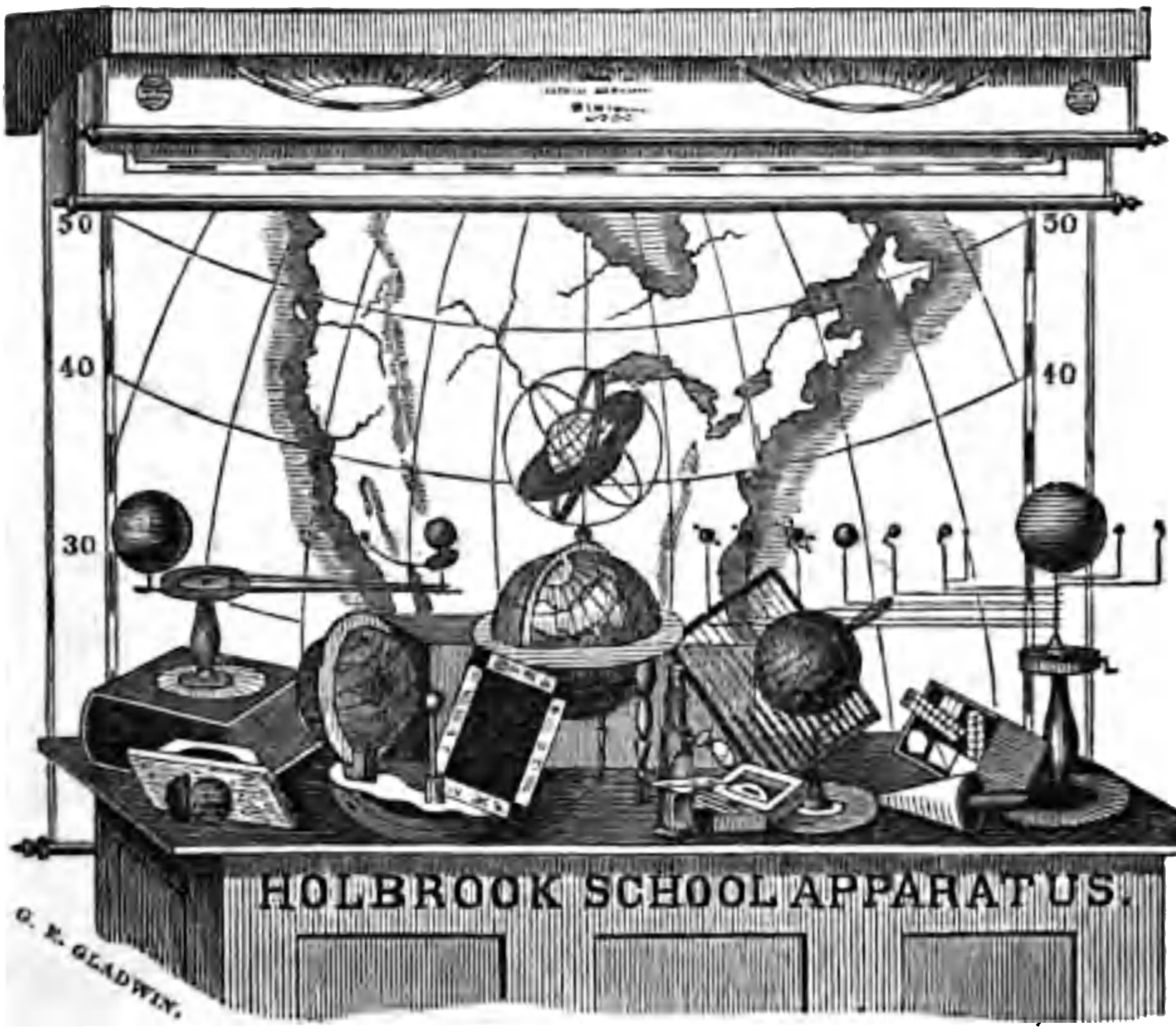
TEACHER'S

GUIDE TO ILLUSTRATION:

A MANUAL

TO ACCOMPANY

Holbrook's School Apparatus.



BY F. C. BROWNELL.

"Precepts and rules are repulsive to a child, but happy illustration winneth him."

"THINGS teach with double force; through the animal eye and through the mind And the *eye* catcheth in an instant what the *ear* shall not learn within an hour."

FOURTH EDITION.

HOLBROOK SCHOOL APPARATUS COMPANY,

NEW YORK AND CHICAGO

1861.

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PREFACE.

EXPERIENCE and observation afford abundant proof that ILLUSTRATION is the basis of successful teaching; and, in physical science, *visible* illustrations are the most convincing. On this point, those best acquainted with the laws of mental growth agree with those most skilled in the art of imparting instruction, and the higher institutions of learning universally recognize this principle by making ample provision for such illustrations.

Is similar provision made for the PUBLIC SCHOOLS of the several States? Are maps, globes, and other, even *simple*, instruments found in them? Is not the remark too frequently made that teachers do not know how to use such articles?

This work, prepared for teachers, explains various phenomena connected with studies usually pursued in the common school, and gives simple but satisfactory methods of illustrating them to pupils. Its design is not so much to instruct as to suggest; leaving it to the teacher to invent other modes, suited to the necessities of his pupils.

Though it is primarily designed as a manual,

to accompany Holbrook's School Apparatus, many of its illustrations are adapted to the simple globe, or can be given by apparatus which the ingenious teacher can make for himself. They are not the result of mere theory, but of the author's practical experience in the school-room.

Attention is invited to the sections on Map Drawing and Topical Geography. An Appendix to Part II. gives full directions for the use of globes. The copious Index will facilitate reference.

In preparing this Manual, the author has consulted various astronomical treatises, and has derived much assistance from the "Elements of Astronomy," by Prof. John Brocklesby. By the courtesy of the publishers of that work, he has been permitted to use several of their wood cuts, (all those having a black ground,) which have contributed materially to the distinctness of the explanations and illustrations. From these cuts, and the accompanying extracts, teachers will readily discover the superior merit of the "Elements of Astronomy" as a class-book. Most of the section upon Topical Geography was taken from a "Text-Book to accompany Holbrook's Scientific Apparatus," prepared by Alfred Holbrook, Esq. Part II. is also arranged on a similar plan with that work, and derives from it much of its interest and value.

Hartford, August 30th, 1858.

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HOLBROOK'S

AMERICAN SCHOOL APPARATUS.

INTRODUCTORY.

THE Apparatus for Schools and Families, devised and prepared by Mr. JOSIAH HOLBROOK, several years since, and extensively used in this and other countries, has recently been much improved. It provides large and varied exercises for the eye and hand, in practical lessons on the laws and works of our Creator; and, thus secures the most solid improvement for the pupil, while producing visible and tangible illustrations, full of instruction and interest.

Mr. Holbrook labored to secure the general use of the means of visible illustration in schools and families, knowing that, in so doing, he would benefit both teachers and pupils, and make a decided step in educational progress.

The strength of his best days was given to this object. By lectures, by printing and circulating papers on this subject at a pecuniary loss to himself, by his own teachings to a model class and to the children in his various places of residence, and by public exhibitions of their proficiency, he sought to prove to community, what he fully believed: that apparatus was a *necessity* for the schoolroom rather than a toy or a luxury. Boston, New York, and Washington were, at different times, the centers of his labors. He constructed most of the articles which now

bear his name, and which have ever received the cordial approval of the best teachers and educators, and, but for his untimely death, he might now rejoice to see them, universally appreciated and extensively used. This pleasure is reserved for his son, MR. DWIGHT HOLBROOK, who continues to manufacture the articles originated by his father, and has made numerous improvements and additions.

Before these articles appeared, apparatus was in use in colleges, and to some extent in academies and high schools; but, of such expensive character that it was entirely beyond the reach of common schools; indeed, very little of it was designed to illustrate those branches taught in common schools.

'Tis true, that globes could be had for ten dollars, and more; that orreries were constructed at an expense of hundreds or thousands; that air-pumps and electrical machines were imported for colleges, and rarely for acade mies; but it yet remained to bring apparatus within the reach of the million; first, by devising instruments adapted to the grade of studies pursued in common schools; and, secondly, by constructing them in so cheap and durable a manner as to bring them within the means of the poorest district in the country.

How well this has been accomplished is best shown by the many district and private schools and academies already supplied, and by the constantly increasing demand for "HOLBROOK'S APPARATUS."

Is it not time that globes, maps, magnets, microscopes, and similar articles should be used in *every* school-room?

Ought they not also to be found in the family to aid that fireside instruction which imparts so much zest for *daily study at school*?

ADVANTAGES OF APPARATUS.

MAXIM I.—WHAT IS SEEN IS BEST UNDERSTOOD.

Apparatus, teaching by the eye, and giving more definite and correct impressions than can possibly be conveyed by language, is the best means for making the sciences well understood.

MAXIM II.—WHAT IS UNDERSTOOD, INTERESTS.

Hence, apparatus increases a love of learning, of books, and of schools; promotes industry and good order in pupils, and secures their continued improvement after closing their school education.

MAXIM III.—WHAT INTERESTS, IS BEST REMEMBERED.

The knowledge acquired by the aid of apparatus will be permanent. It does not depend on the memory of certain words, which, when learned, convey no clear conception of what they were designed to teach; but the pupil, having seen, understood, and been interested in the matter taught, will retain it vivid and distinct through life.

MAXIM IV.—PRINCIPLES ARE BETTER THAN RULES.

By giving the principle,—i.e. *the reason of the rule*,—instead of the rule, apparatus imparts knowledge in place of mere information.

What the mind thus acquires is not inert, like a collection of dates and statistics, but a living power, suggesting thought, leading to investigation, analysis and combination of principles and powers, *and to consequent invention*.

On the foregoing it is easy to base

MAXIM V.—ILLUSTRATION IS THE BASIS OF SUCCESSFUL TEACHING

"The abundance of one's intellectual knowledge, and the degree of his mental improvement, will depend somewhat on the number of his ideas of sense, but *more* on the *distinctness* with which the mind perceives them." * * *

"It is well-known that the ideas of some of the senses are more distinct than those of others." * * *

"There is a greater probability of getting access to a child's mind through the eye than through either of the other perceiving organs." * * * * *

"It must be evident, from these remarks, that it is exceedingly important for teachers, while they explain a matter to their pupils by words that fall on the ear, to present it at the same time to the eye. The fact that teaching by *visible illustrations* is so strictly in accordance with the established principles of intellectual philosophy, and, whenever used, has always been beneficial, recommends it to the attention and practice of every teacher of Common Schools."—(*Teacher Taught.*)

"There is another point, where, as it seems to me, a united effort among the friends of education would, in certain branches of instruction, increase ten-fold the efficiency of our Common Schools. I mean the use of some simple apparatus so as to employ the eye more than the ear in the acquisition of knowledge." * * * * *

"The mind often acquires, by a glance of the eye, what volumes of books and months of study could not reveal so livingly through the ear. Everything that comes through the eye, too, has a vividness, a clear outline, a just collocation of parts, each in its proper place, which the other senses can never communicate. Ideas or impressions acquired through vision are long-lived." * * * * *

"At the last session of the (Mass.) Legislature, a law was enacted, authorizing school-districts to raise money for the purchase of apparatus and common school libraries for the use of the children, to be expended in sums not exceeding thirty dollars for the first year, and ten dollars for any succeeding year. Trifling as this may appear, yet I regard the law as *hardly second in importance* to any which has been passed since the year 1647, when Common Schools were established."—(*Lectures on Education by Horace Mann.*)

ADVANTAGES OF HOLBROOK'S APPARATUS.

In addition to the benefits already mentioned, and which apply to apparatus in general, Holbrook's apparatus is specially designed to illustrate the subjects taught in all grades of public schools, and combines economy and durability. The COMMON SCHOOL SET embraces

1. FOR ARITHMETIC, a Numeral Frame, with movable balls or counters, to be used in teaching Numeration, Addition, Subtraction, Multiplication, Division, and Fractions. (See page 21.) Also, blocks to give examples in solid measurement, to show the rapid increase of cubes, and to illustrate the extraction of the Square and Cube Roots. (See p. 29, 40.)

2. FOR GEOGRAPHY, a Globe, (page 45,) a Hemisphere Globe, (page 49,) and a Tellurian, (page 66.) This last is of great value for Astronomy also

3. FOR GEOMETRY, solids representing various geometrical figures, (page 29,) and illustrating the Carpenter's Theorem, &c., (page 31.)

4. FOR ASTRONOMY, an Orrery, (page 70,) representing the solar system, and the Tellurian, (page 66.)

5. ALSO A MAGNET, which will be a source of endless amusement and interest, besides affording, probably, the only means of giving to children a proper idea of attraction.

6. A TEXT BOOK or GUIDE TO ILLUSTRATION also accompanies the set, showing the manner of adjusting the apparatus, modes of using it to explain various phenomena, and suggesting much that will be interesting and instructive to pupils in the branches of study for which it is adapted.

This set is safely packed in a neat box, with lock and key, and fitted for transportation to any distance.

Other articles, not included in the set, are mentioned on page 19, and will be found in the index, and in Part II.

OBJECTIONS ANSWERED.

1. "*We cannot afford to purchase apparatus. Our school costs now more than we are really able to pay.*"

As well might the mechanic or the farmer say he can not afford to buy the tools which, by saving time and labor, soon pay for themselves.

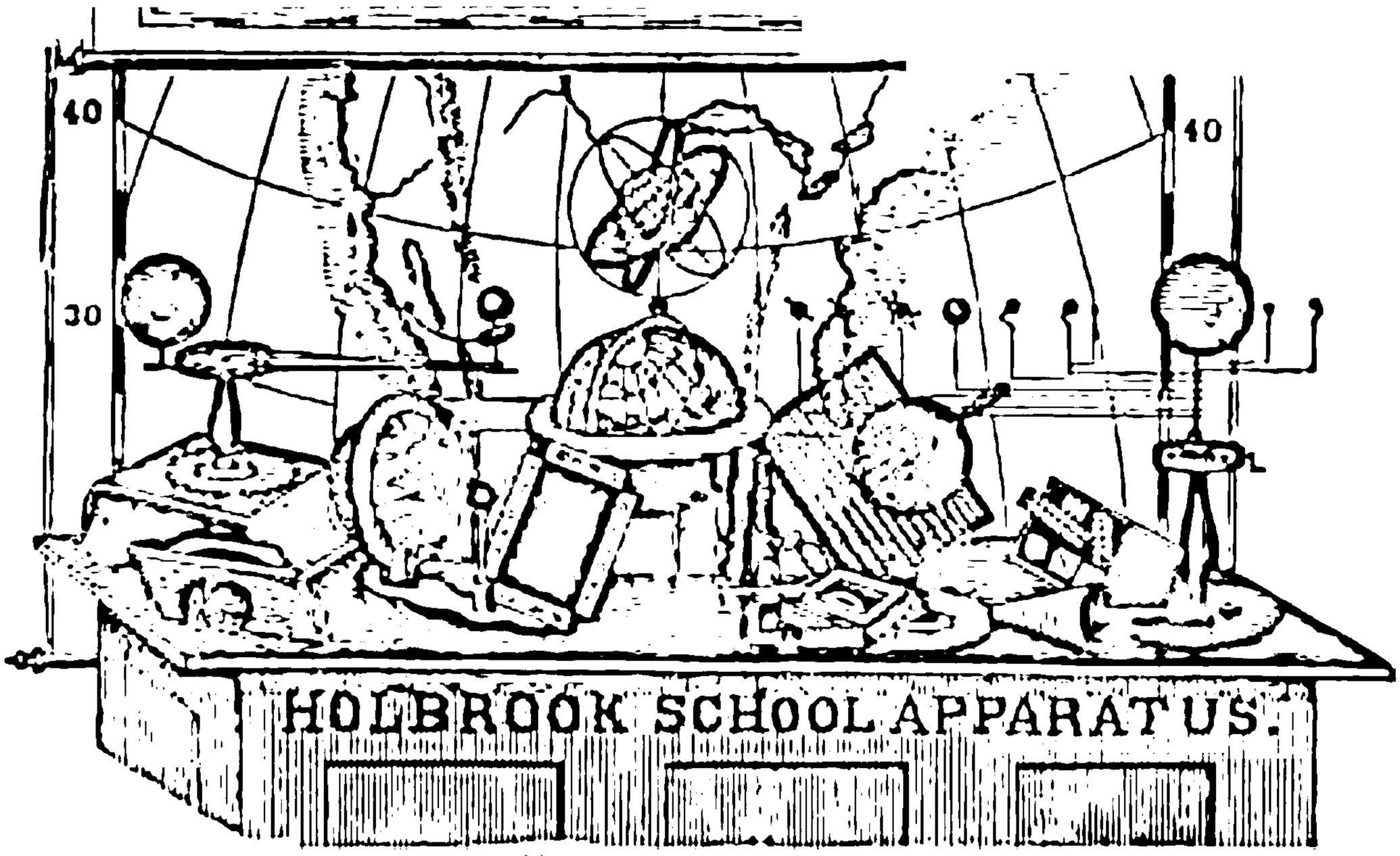
The very end apparatus aims at is to save time, labor, and consequent expense; and this it never fails to do in the hands of any teacher who is worthy to be intrusted with the education of children.

2. "*The apparatus, if purchased, would soon be broken and destroyed.*"

Place it in the care of the teacher; furnish him a case, with lock and key, suitable to contain it; (see page 20.) If he is fit for a teacher, you may be sure the apparatus will be safe.

3. "*Teachers will not use it. Many do not know how.*"

Good teachers *will use it.* If, at first, some are ignorant of the manner of illustrating with it, the Text-book will soon teach them; and the daily exercises with their classes will suggest many uses not mentioned in any book. The very ignorance complained of shows that hitherto apparatus has not had its proper place even where teachers have been educated. Let it be repeated, GOOD TEACHERS WILL USE APPARATUS, EVEN IF OBLIGED TO BUY OR MAKE IT



Holbrook School Apparatus Company

OFFICES, { 25 Howard St., New York, . . F. C. BROWNELL, Sec'y.
118 Lake St., Chicago, . . . GEO. SHERWOOD, Pres.

PRICE LIST, January, 1861.

No. 1.	Orrery,	$10.00	
" 2.	Brass Orrery,	12.50	
" 3.	Best Brass Orrery,	15.00	
" 4.	Tellurian,		
" 5.	Geared Tellurian,	8.00	
" 6.	Brass Geared Tellurian,	10.00	
" 7.	Brass " " nicer,	12.50	
" 8.	Brass " " best,	15.00	
" 9.	Celestial Sphere,	8.00	
" 10.	Celestial Sphere, with sections,		
" 11.	Gyroscope, two rings,	5.00	
" 12.	Gyroscope, three rings,	8.00	
" 13.	Gyroscope, " " best,	10.00	
" 14.	Barnard's Expla'tion of Gyroscope,	.25	
" 14a.	Snell's Explanation of "	.25	
" 15.	Pyrometer, $4.00 and	5.00	
" 15a.	Terrestrial Globe, (3-inch,)	1.00	
" 16.	Primary School Globe, (5-inch,)	1.50	
" 17.	Terrestrial Globe, (8-inch,)	5.50	
" 18.	Do., Brass Mounted, in Meridian,	8.00	
" 18a.	Do., with Horizon and Quadrant,	10.00	
" 19	Hemisphere Globe, (3-inch,)	1.00	
" 20.	Hemisphere Globe, (5-inch,)	1.50	
" 21.	Dissected Cone,	1.50	
" 22.	Do., with colored sections,	2.00	
" 23	Geometrical Forms, large,	2.50	
" 23a.	Shepherd's Decimal Blocks,	2.50	
" 23b.	Geometrical Forms,	1.00	
" 24.	Arithmetical Solids,	1.00	
" 25.	Geom. Forms and Arith. Solids,	1.50	
" 25a.	Do " in wood box,	2.00	
" 25b.	Object-Teaching Forms,	2.00	
" 26.	Numeral Frame, 100 balls,	.63	
" 27.	Numeral Frame, 144 "	.75	
" 28.	Cube Root Blocks,	.50	
" 29.	Double Cube Root Blocks,	.75	
" 30.	Sixty-Four Inch Cubes,	2.00	
" 31.	Magnets, .25, .50, .75 and	1.00	
" 32.	Pointing Rods, .25 and	.50	
" 33.	" " extra long,	.75	
" 34.	*Blackboard Rubbers, No. 1,*	.30	
" "	*Do., larger, No. 2,*	.40	
" "	*Do., largest, No. 3,*	.50	
" 35.	*Alphabet Blocks,*	.75	
No. 36.	Alphabet Blocks, Cubes,	1.	
" 37.	Glass Ink Wells, per doz.,	$.	
" 37a.	Do., with iron covers, per doz.,	1.	
" 37b.	Glass Ink Wells, in metal, "	2	
" 38.	Perfection Ink Wells, "	2	
" 39.	Glass Pump,	2	
" 39a.	Glass Forcing Pump,	3	
" 40.	Glass Syphons, .25, .50 and		
" 41.	Primary Drawing Slate, No. 1,		
" "	" " " No. 2,		
" 41a.	Boston Primary Slate, No. 1,		
" "	" " " No. 2,		
" 41b.	Paper N. Y. Drawing Slate,		
" 41c.	Paper Boston " "		
" 42.	High School Slate, No. 1,		
" "	" " " No. 2,		
" 43.	Double " " No. 1,		
" "	Double " " No. 2,		
" 44.	Progressive Drawing Lessons,		
" 45.	Primary Drawing Book,		
" 46.	Teacher's Letter to Parents, per hundred,	2.	
" 47.	Universal School Register, .25, .50, .75 and	1.	
" 47a.	Class Register, .25, .38 and		
" 48.	First Lessons in Astronomy,		
" 49.	Teacher's Guide to Illustration,		
" 50.	Letter Table, on stand,	15.	
" 51.	Figure Table, large,	4.	
" 52.	Letter Table,	2.	
" 53.	" " smaller,	1.	
" 54.	" " "	1	
" 55.	" " "	1.	
" 56.	" " "		
" 57.	Figure Table,		
" 58.	" "		
" 59.	Large Numeral Frame, on stand,	10.	
" 60	Newell's Patent Spelling Box,	1.	
" 61.	Brown's Primary Instructor,		
" 62.	Liquid Slate for Blackboards, gall.,		

PRIMARY SCHOOL SET,

INTERMEDIATE SCHOOL SET,

GRAMMAR OR COMMON SCHOOL SET,

HIGH SCHOOL SET,

The COMMON SCHOOL SET is packed in a neat box, with lock and key, in which it can be sent any distance with entire safety. The box is not designed, however, as a permanent case for the set, as this would require the apparatus to be adjusted and repacked every time it is used.

A suitable case for the set can be easily made by any carpenter. One of the following dimensions, viz.: height 3 feet,—divided midway by a shelf,—width 3 feet, depth 8 inches, makes a very convenient case for this set, and also gives room for a small cabinet of minerals or curiosities, which pupils should be encouraged to collect and contribute. It should be kept locked, but should have a glass door, that all the articles may be distinctly seen.

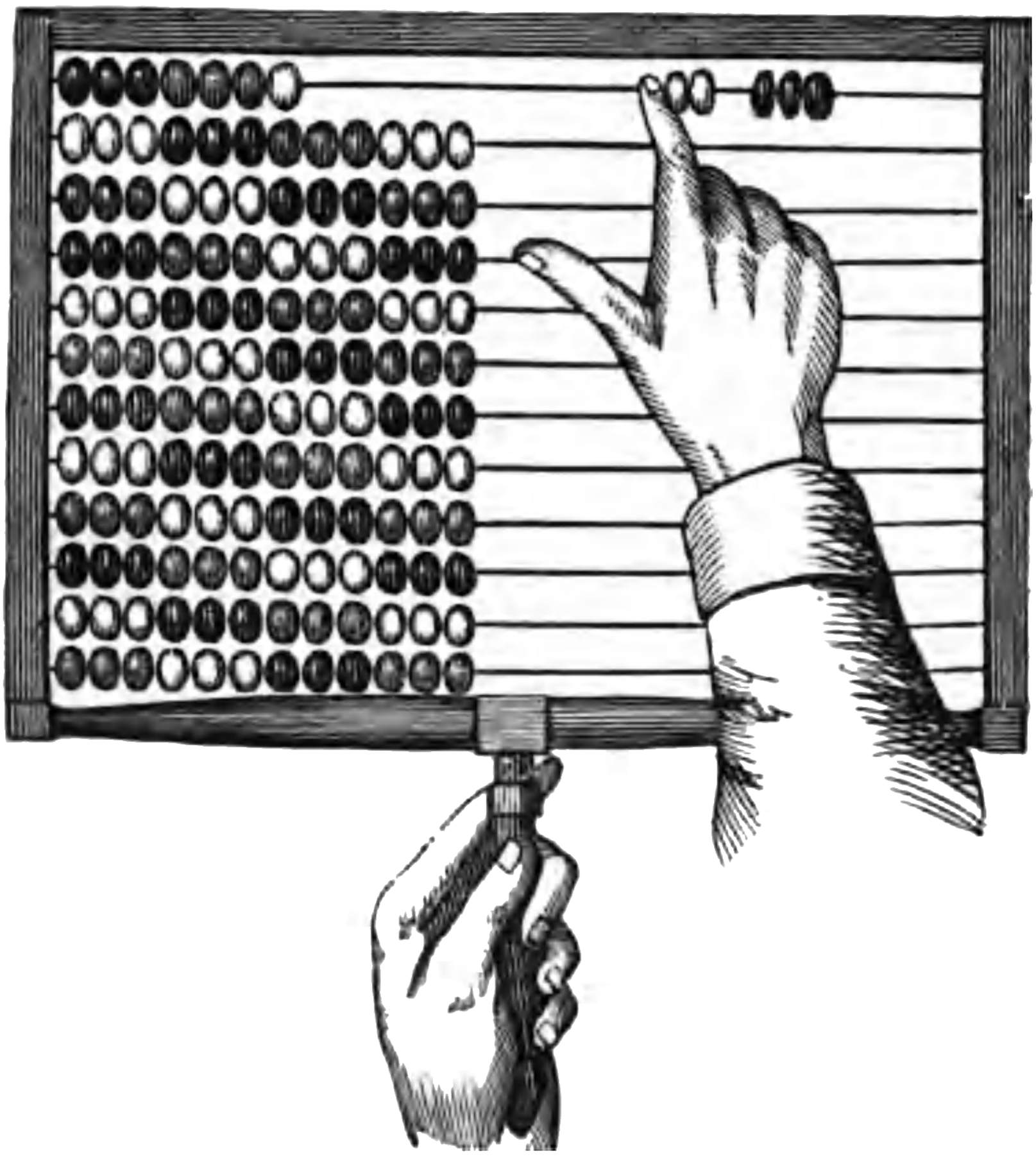
The shelf should be made movable, which can be done by inserting strips of heavy tin in saw-cuts, (half an inch deep,) on each side of the case, on which it may rest. There may be several saw-cuts on each side, at distances of an inch, allowing the tins to be raised or lowered with perfect ease.

The back of the case should be painted black, and provided with hooks for suspending small articles, which may form the cabinet of curiosities.

Children should not be permitted to handle any apparatus except by express permission, and under the eye of the teacher. If any portion of apparatus is not in complete working order, a little care, thought, and patient ingenuity on the part of the teacher will, in most cases, discover the difficulty, and enable him to remove it. If not, it should be laid aside till some proper person can examine it. It should not be placed in careless hands for repairs.

I. NUMERAL FRAME.

FIG. 2.



THE Numeral Frame was designed for Primary Schools, but has proved of nearly equal service in intermediate and grammar schools; wherever young pupils require illustrations to enable them fully to comprehend operations with abstract mathematical quantities, this frame furnishes the readiest mode of giving the desired instruction.

A few suggestions as to its use will be given.

1. For teaching how to count.

"The teacher, holding the frame so that the balls are all on one side, and passing one of those on the upper wire across to the opposite side, says 'There is one ball. Repeat after me, one ball; (passing another across,) two balls;' &c., till all are passed across, and named. Then repeat the operation, omitting

the word *ball*, till all can readily count from one to ten. The class then should be told that ten has three different names, viz.:—

1. One ten standing by itself is called . . . ten.
2. One ten joined to another number, . . . teen.
3. More than one ten, ... ty.

Applying this to the frame, pass ten balls on the first wire across and then say, 'There is ten.' Now, one ball across from the second wire, 'There is *oneteen*; another will make *twoteen*; three, *threeteen*; four, *fourteen*,' &c., to nineteen; and then, passing the last one across, 'Now we have *twoty*.' Then, by passing the balls of the third wire singly across, we shall have *twoty-one*, *twoty-two*, &c., to *threety*; and, continuing the operation, *fourty*, *fivety*, *sixty*, &c., to *ninety-nine*; the last ball gives *tenty*, or a hundred.

When they have become familiar with these names, which will be in three or four lessons, the abbreviations, which are few and simple, may be explained.

The most difficult are the first two, *oneteen*, *twoteen*, which are changed to *eleven*, *twelve*; the others are very simple, viz.: *threeteen* and *threety* are shortened to *thirteen* and *thirty*; *fiveteen* and *fivety* to fifteen and fifty; lastly, *twoty* is *twenty*, and *fourty* is *forty*.

This explanation is principally intended for those who know nothing of arithmetic; but, it would be profitable for the whole school to go over the frame once or twice, as there are few who have clear notions of the meaning of *ty* and *teen*."—(*Palmer's Manual.*)

2. For exercises in addition and multiplication. For example, the teacher, standing before the class, holding the frame, requests all to see how many balls he moves; he then moves out two each time, and the class count in concert, two, four, six, &c. Next time more rapidly, till the counting by two's, or *adding*, is performed as fast as the teacher can move the balls. To give life and pleasure to the exercise, as well as to secure close attention, require the pupils to count with precision when the balls move, and *only* then; and, occasionally stop when they do not expect it. If any are counting mechanically, or

without attention, they will be "caught," which should be treated as a joke, not a sin. You will not catch them many times.

The proper use of the visible counters of the Numeral Frame will infallibly break up the sing-song of tables and associate ideas with the words used.

If it be said the teacher cannot move balls rapidly enough and yet be accurate in the number, it should be remembered that the scholars, as soon as they can answer fast, will not *count* the balls, and it will make no difference with them whether *two* or *four* are moved at a time; they have begun real mental addition, and the teacher, without being aware of it, perhaps, has accomplished *just what was wanted*,—just what is done by memorizing the addition table,—and the scholars have understood and enjoyed it.

At leisure times let one of the class take the frame and try to "puzzle" the rest.

"But what shall the scholars study? They will need no tables, it would seem, in this way."

The exercise on two's has been given them to-day. Don't expect them to learn it in *one* day. Mark on the board like this ' | ' | ' | ' | one short mark and one long; and, pointing at the long ones, have them add, two, four, six, eight, &c., and require them to bring, on their slates, at the next recitation, marks in the same way, to a certain number, say 100, *and* to be able to add them; this will incite them to study, as may be found by a short trial. Begin sometimes with the short mark, and add one, three, five, &c. What will do for "two's" is equally good for "three's," or "four's."

The same method, with a little adaptation, may be used

to teach Multiplication. If, afterwards, the Multiplication Table is desired, it will be found an easy task to memorize it perfectly.

In a Grammar School.—A class in Reduction can not see *why* "144 sq. in. make one sq. foot," or "9 sq. feet one sq. yard." Take the numeral frame and move out three balls on each of three adjacent wires, making a square. Tell them to call each ball a foot, then three feet (or balls,) make a yard one way, and the same the other way. Ask if it is not a *square* yard, and then have them count the number of feet in it. Will they ever forget it?

Or, a class beginning fractions do not know which is largest, a third, fourth, or sixth. On one wire move out twelve balls, compactly; below, twelve more divided into halves; below, twelve in thirds, and so on to twelfths. The twelve compact balls represent a unit; the next twelve a unit divided into halves, &c.

Present these units, so divided, to the class with questions such as the following: How many halves in a unit? How many thirds? Which unit is divided into halves: which into thirds? How many quarters, etc.? Which is the largest or worth the most, a half or a third, a quarter or a sixth, a sixth or a twelfth?

What pupil will not see plainly the relative sizes (or values) of the different fractions, and also understand *why* it is so?

Again, in addition of fractions, take two thirds and three quarters, as fractional quantities to be added. They neither make five thirds nor five quarters: what do they make? We cannot add them in the form of thirds and quarters any more than we can add two dollars and three

dimes together. But, as we can change dollars and dimes to cents, and then add them, so we can change or reduce the thirds and quarters to twelfths, and add them. This change can be illustrated by the frame most perfectly

The questions annexed to this article will furnish other suggestions; and thought, in connection with daily class exercises, will find many ways of using this simple instrument.

QUESTIONS ON NUMERAL FRAME.

How many are one and one—two and two—three and one—four and one? If one be taken from one, how many? One from two—one from three—two from three? &c. Questions like the following give great facility in combining numbers: Seven and five, how many—seventeen and five—twenty-seven and five—thirty-seven and five? &c. Nine and seven, how many—nineteen and seven—twenty-nine and seven?—extending it to ninety-nine and seven. Applying this exercise to a great variety of combinations, carrying each from the elementary digits up to a hundred, renders the pupil expert in practical Arithmetic.

How many are once one? How many are twice one? How many ones in two? What part of two is one? How many is one half of two? How many are two "two's?" How many "two's" in four? What part of four in two? How many are half of four? How many are three "two's?" How many "two's" in six? What part of six is two? What part of six is two "two's," or four? How many thirds of six are three "two's?" What part of six is three-thirds?

How many are four "two's?" How many "two's" in eight? What part of eight is two? What part of four is two "two's?" What part of eight is two fourths? What part of eight is three "two's," or six? How many fourths of eight are four "two's?" What part of eight is four fourths? How many are five two's? &c., &c. Proceed in the same way to ten or twelve "two's."

How many are three "one's?" How many "one's" in three? How many is one third of three? Two thirds? three thirds? What part of three are three thirds? How many are two "three's?" How many "three's" in six? What part of six is three? How many are one half of six? How many are three "three's?" How many "three's" in nine?

What number multiplied by itself produces one? One. What is the square of one? What number multiplied by itself produces four? What is the square of two? What the square root of four?* What is the square of six? The square root of thirty-six? Of what numbers are seven, eight, nine, and ten the square roots?

Exercises enough have been given to indicate the course proposed. Every teacher will know how to adapt these suggestions to his own school. By such questions, greatly extended and varied,—at first aided by the Numeral Frame,—the pupil becomes so strong and familiar in the whole ground-work of numbers, in all their departments, as to act intelligently in any question he may be called to solve.

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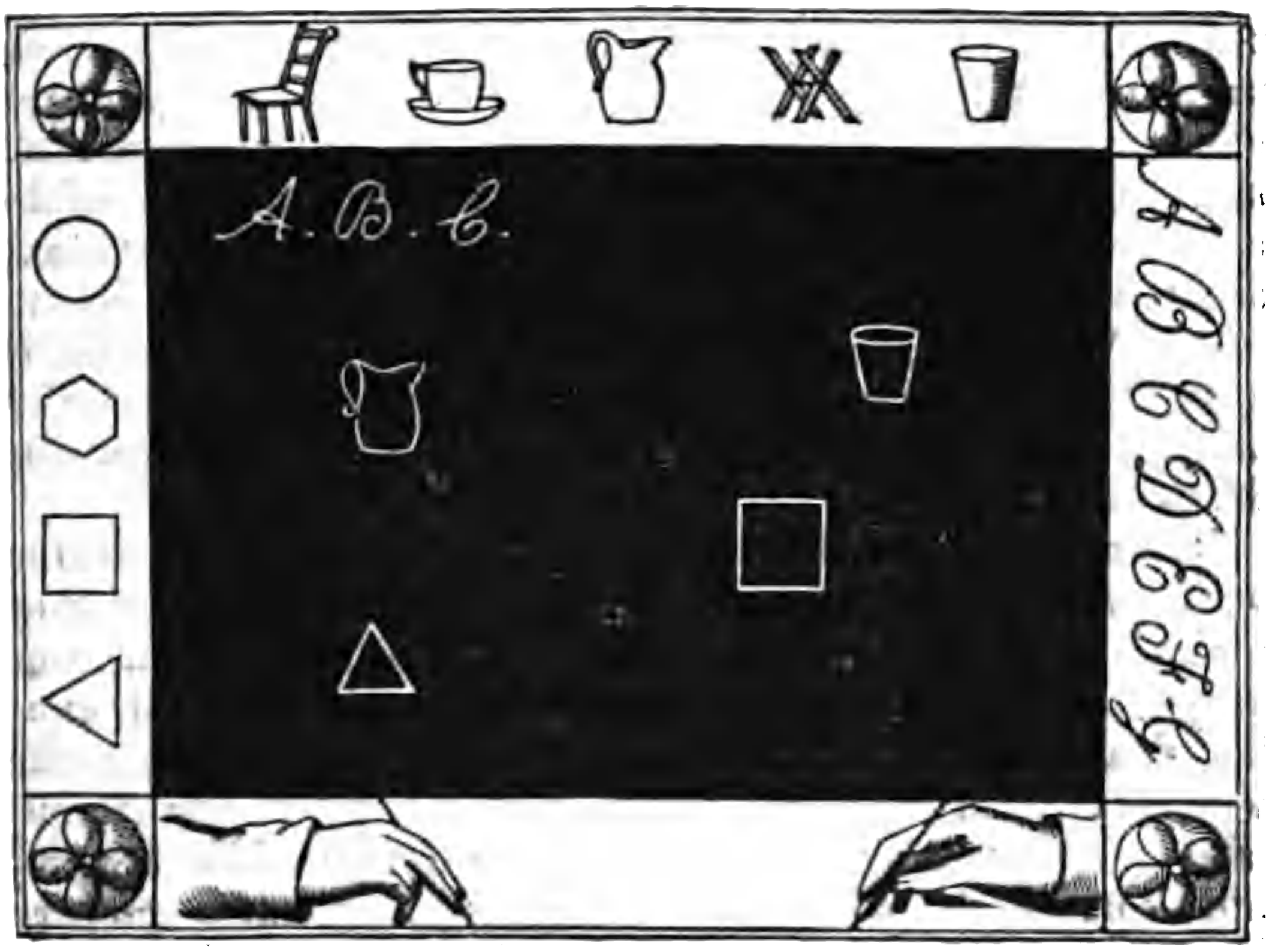
* For the square of two, place two balls on each of two adjacent wires, forming a square, or four: the length of one side of this square is its root.

II. HOLBROOK'S PRIMARY DRAWING SLATE.

FIG. 3.



Teaches the right manner of holding the pen; gives copies of writing letters, both small and capitals; furnishes a variety of drawing copies,—which are much extended in the DRAWING BOOK, prepared to accompany the slate;—it answers every purpose of the ordinary slate; *and* is NOISELESS. This Slate and the Boston Primary Slates on the same plan, have been introduced in the Primary Schools of Boston, Albany, San Francisco, and other important cities. An abundance of additional drawings is provided in the Primary Drawing Book, and the Progressive Drawing Lessons from familiar objects.

Some extracts will show the value of drawing, as estimated by some of the best educational authority.

"Experience has fully demonstrated that Drawing may be introduced into Infant and Primary Schools with great benefit to the children, and with beneficial effect upon the discipline of the schools. Every child, however young, should have a slate, and it will require no great skill on the part of the teacher to chalk some familiar object on the blackboard, and request those *children not otherwise* engaged to copy it."—Fowle's Teachers'

"Drawing should be taught simultaneously with writing; that is, as soon as the pupil can hold a pencil. It should be practised, at first, on the slate, on which the very youngest child may be usefully employed, in forming vertical, horizontal, and oblique lines, triangles, squares, rectangles, &c." 'Without drawing there can be no writing,' was a saying of Pestalozzi; and though it is somewhat extravagant, it is, to a great extent, true. Writing is, in fact, a species of linear drawing; and, its acquisition is evidently facilitated by previous exercises in straight and curved lines, circles and ovals."—(*Hints and Methods.*)

"In many schools, children are allowed to commence writing with pen and ink at too early an age. If, instead of this, they should be allowed to draw upon slates or blackboards, such simple models as may be furnished, it would prove far more beneficial to them. Let them be allowed to copy letters in this way, as soon as they are old enough to attend school; and, after the lapse of two or three years, during which frequent attention may be given to such exercises, they will be prepared to commence the regular practice of writing under circumstances much more favorable."—(*Northend's Teacher and Parent.*)

"The apparatus of primary school-rooms does not admit of any great variety of lessons; for, often, the little pupil has no desk, and, of course, no opportunity to use rules, pens, and paper. No matter; much may be done without any apparatus but the slate and pencil; much that will be an excellent introduction to the drawing of maps, and to the study of Arithmetic and Geometry."—(*Fowle's Eye and Hand.*)

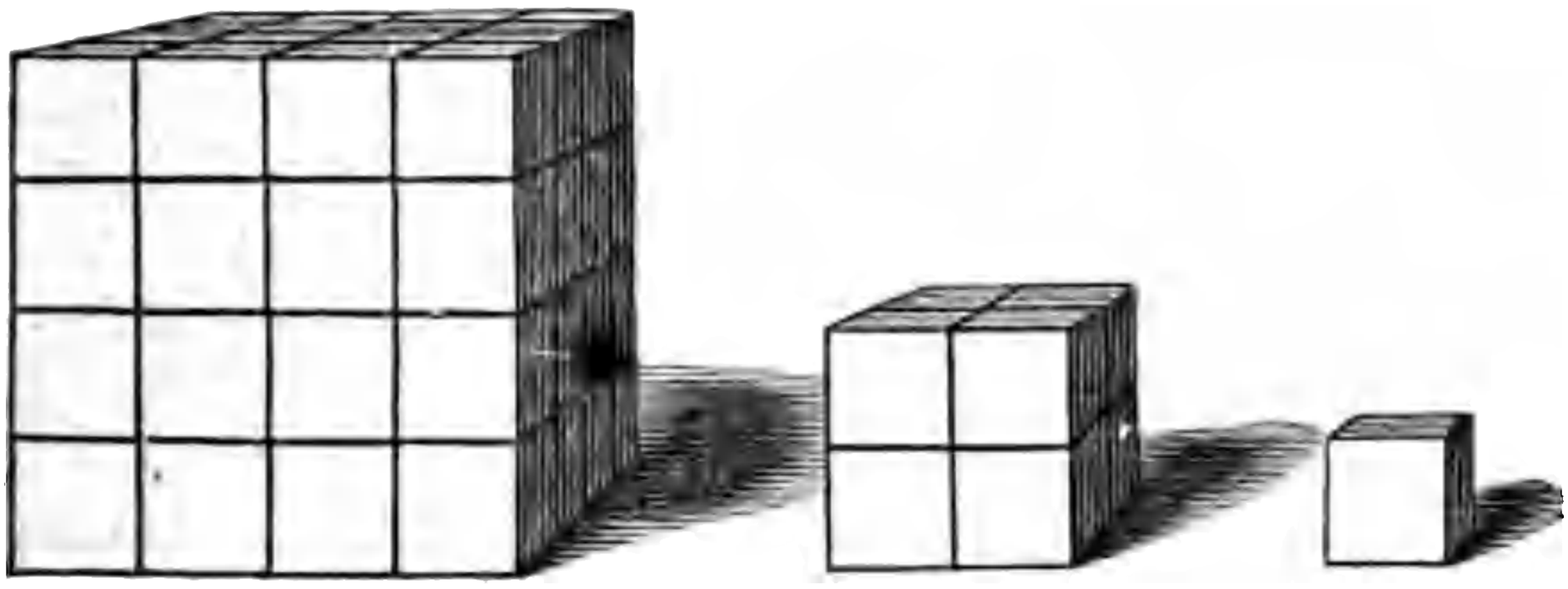
"Ten, twenty, or even five small children, left unemployed, must inevitably cause disorder. But, give them slates and pencils, with convenient desks to lay them on, and a great difference will be seen, even if they are left entirely to themselves. Place before them a few cards with well-formed letters, words, the elementary geometrical figures, drawings of familiar objects, &c., and they will teach themselves something of drawing, and more of the letters, spelling, reading, and writing."—(*Connecticut Common School Journal*, 1838.)

How well these suggestions have been combined in the Drawing Slate can be seen (*partly*) by the cut, and the universal approbation of teachers is a sure testimony to its adaptation to existing wants.

III. GEOMETRICAL SOLIDS.

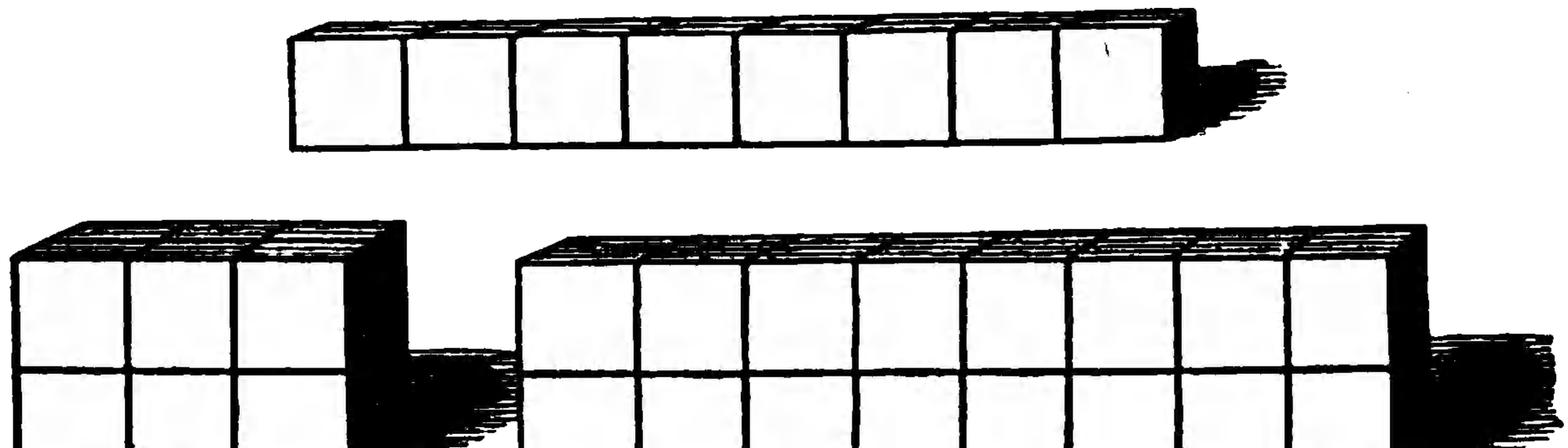
THE GEOMETRICAL SOLIDS will give pupils definite ideas of the shape of solids, far better than pages of description, and much more clearly than any drawings can For explaining the rules for Mensuration or Solid Measurement, they afford the only proper means.

FIG. 4.



CUBES.

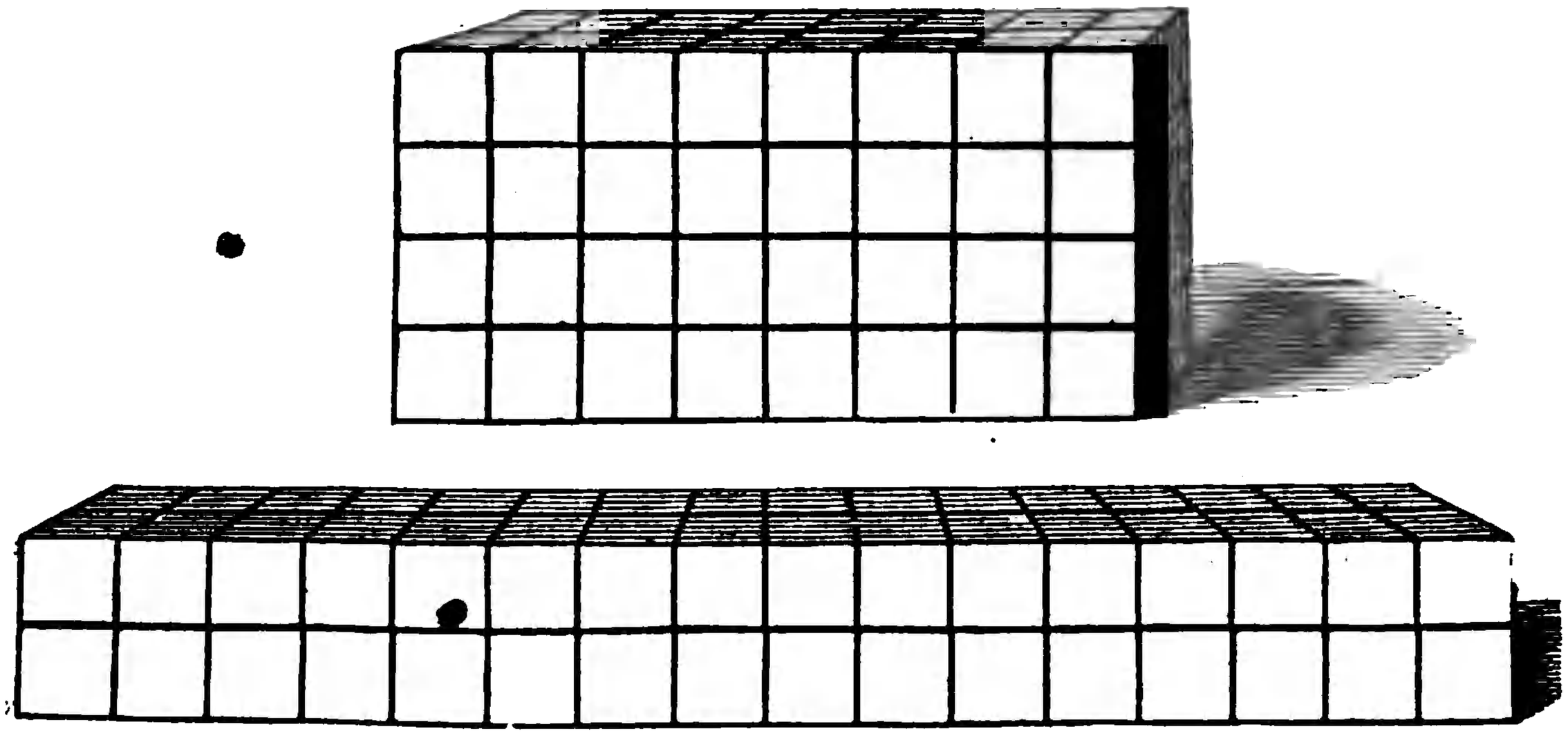
FIG. 5.



PARALLELOPIPEDS.

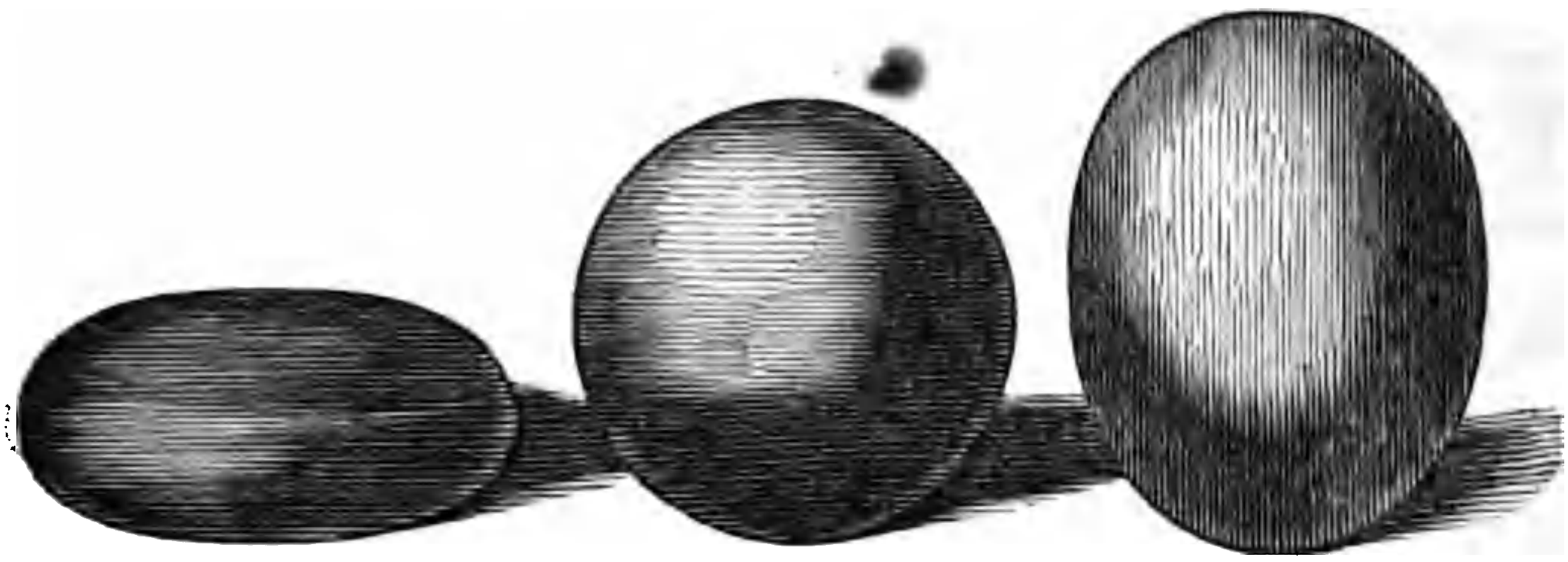
GEOMETRICAL SOLIDS, CONTINUED.

FIG. 6.



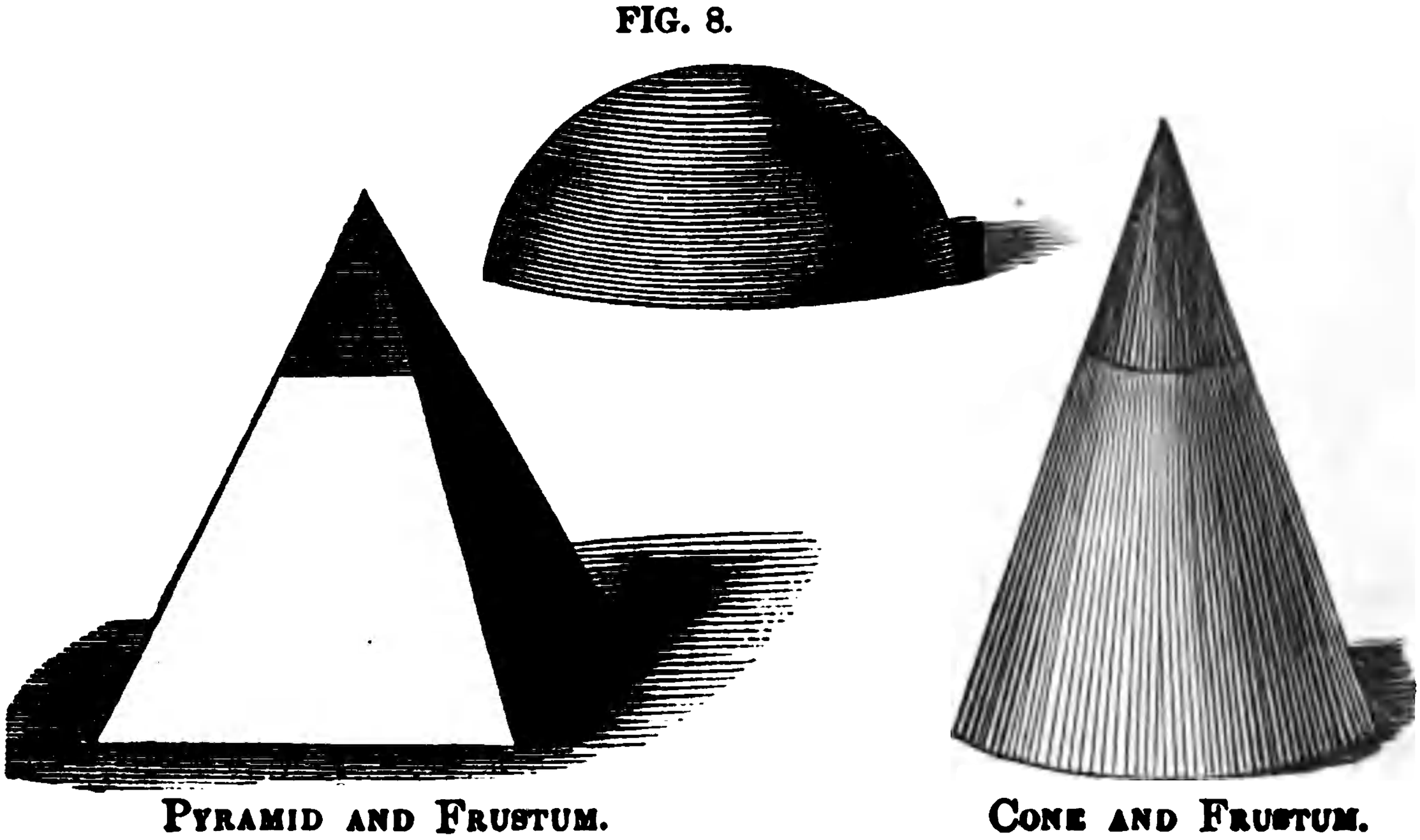
PARALLELOPIPEDS.

FIG. 7.



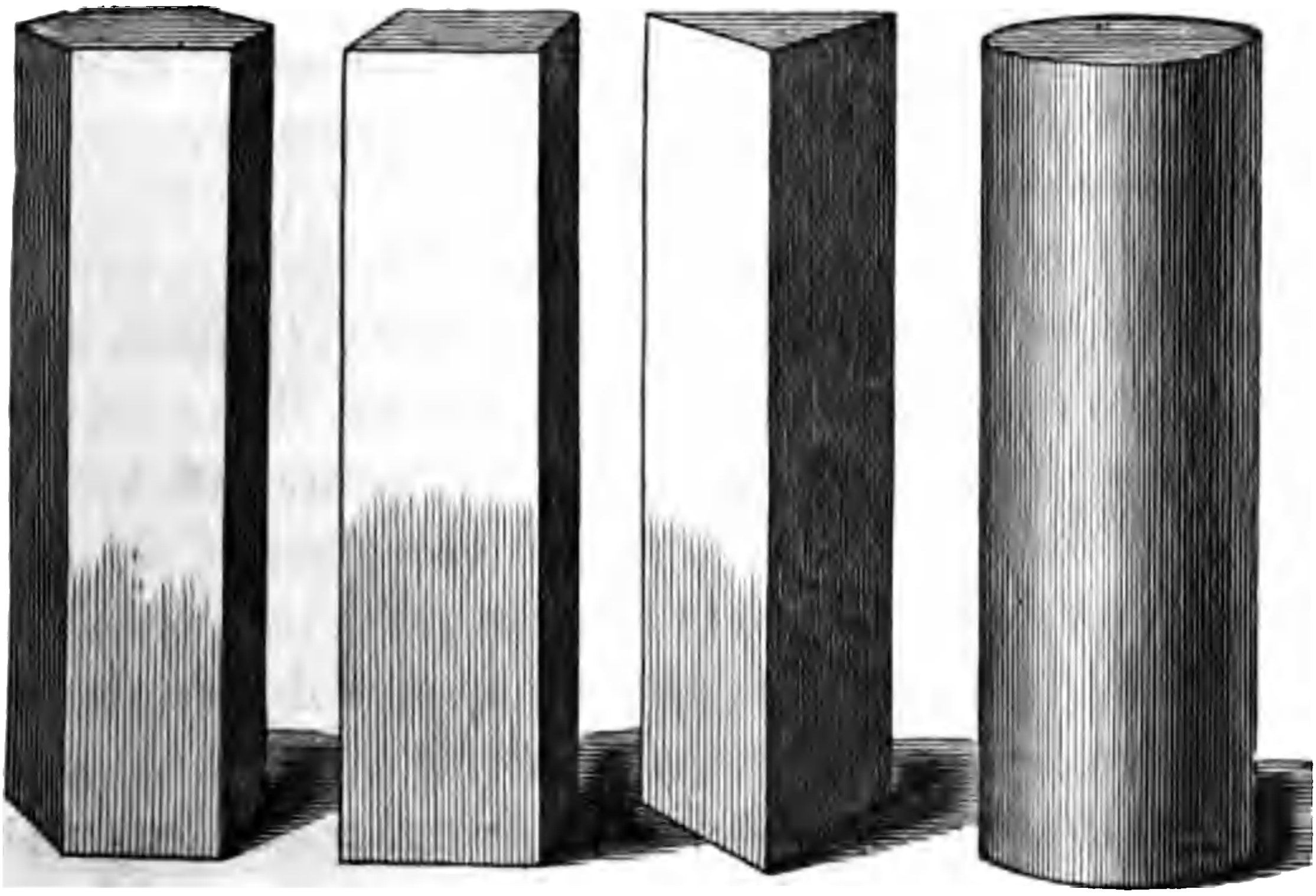
OBLATE SPHEROID. SPHERE. PROLATE SPHEROID.

FIG. 8.



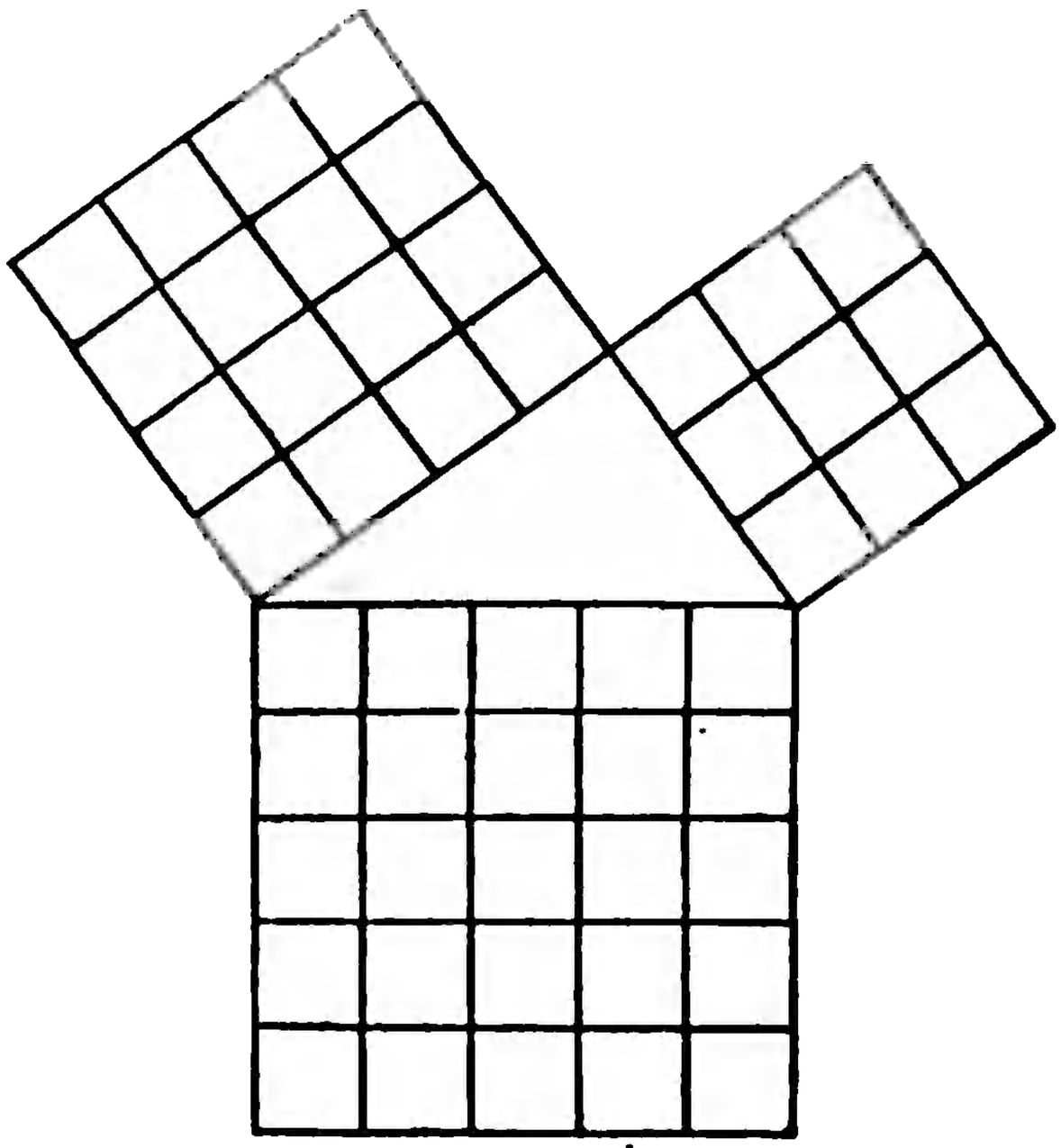
PYRAMID AND FRUSTUM. CONE AND FRUSTUM.

FIG. 9.



HEXAGONAL PRISM. PRISM. TRIANGULAR PRISM. CYLINDER.

FIG. 10.



CARPENTERS' THEOREM.

The first use of these Solids is for definitions. The best definition of the word Cocoanut for a child is—*the nut itself*; so, the best definition for Sphere, Cone, Cube,

Pyramid, or Prism, is the object presented to the eye. For *this purpose* they are most needed in Primary Schools. But, they also afford the best illustrations of square and solid measurement.

1. If each space marked on the rectangular solids be considered a foot or an inch long, it will at once be seen what is meant by a square or a solid foot. The solid foot is shown by the smallest cube. The square foot by *one side* of the same cube. Then, if the surface of the next cube is seen to be *twice* as long and *twice* as wide as the smaller, the child can count for himself and *know* that it contains *four times* as many square feet; or, that one side of the largest cube, though only *four* times as long and wide, contains *sixteen times* as much matter.

2. By the three cubes older pupils can readily see how fast, and *why* cubes increase. Will it not be better than memorizing the rule, "*Cubes increase in proportion to the cubes of their sides?*" Will not the rule be more firmly impressed on the memory by the illustration?

When shown that a Sphere is made from a cube by cutting off the corners, pupils will understand why the above rule also applies to spheres.

3. Let the scholar use these solids as his timber, and measure them, as he may have occasion to do in later life. If he finds the surface of one end of the block,—calling it feet or inches,—he will readily understand that if he goes back one foot, or inch, as the case may be, the surface, or *square* feet, will become *solid* feet, and, if he goes back another foot in length, he will have twice as many, and so on to the end. After this process, his rule, "*Find the area of one end, which, multiplied by the length, will*

give the solid contents," has a reason in it which he never saw before. He can also be shown how to find what amount of boards a particular stick of timber will make.

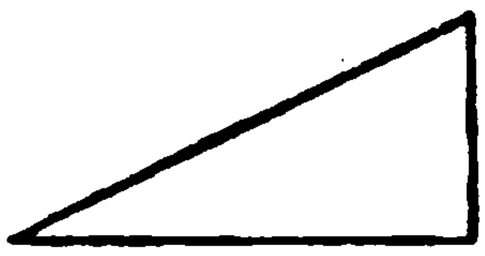
4. To illustrate the rule for finding the surface of a Rhombus or Rhomboid, which reads, "*Multiply the perpendicular by the length.*" If the block representing a rhomboid is separated in the middle, and the two diagonal ends placed together, it forms a perfect rectangle, to which the rule is clearly applicable.*

5. Again, to find the surface of a Prism or Cylinder, the rule reads, "*Multiply the perimeter, i. e.*, the measure around ——, *by the length.*" Let the pupil begin with the triangular prism and find the surface of each side separately as he measures a rectangle; these, added, will give the entire surface. This he will at once understand. He will also see that to multiply the length by the sum of the width of the sides, i.e., the perimeter, is the same in effect. Apply this to all other Prisms, and to the Cylinder, which is really only one side curved.

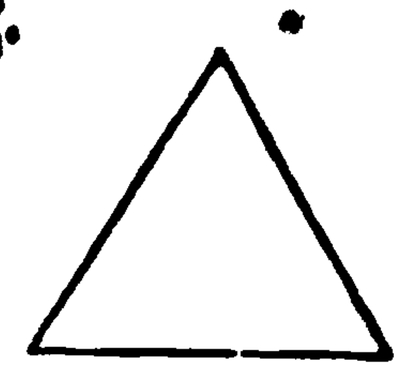
6. The Blocks for illustrating the "Carpenters' Theorem" that "*the square of the hypothenuse of a right-angle-triangle equals the sum of the squares of the other two sides*," will be of service for pupils in more advanced classes in Arithmetic, and though not a demonstration, except for this particular case, it will prove the theorem to many a mind more clearly than all demonstration, because it will be fully comprehended. Many other illustrations, equally forcible, can be given by means of these solids. See also "Lessons on Objects," which follow.

Forms and Solids for Object-Teaching.

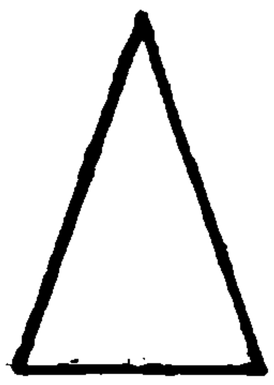
Triangle.



Right-angled Triangle.

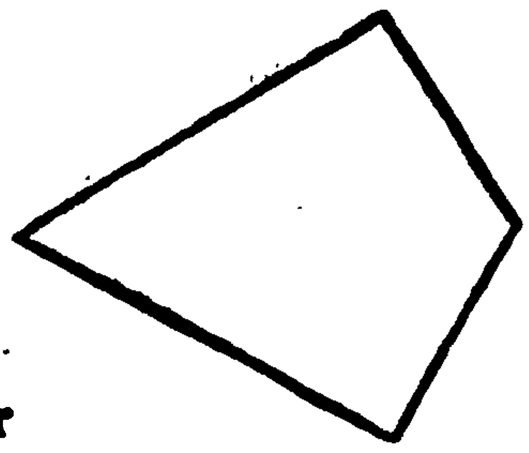


Eqilateral Triangle.

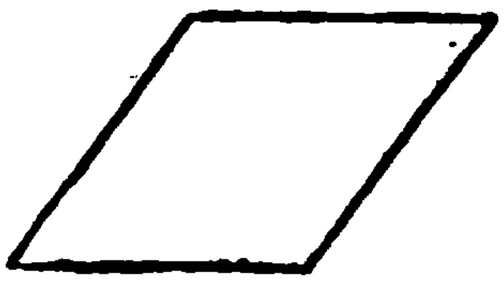


Isosceles Triangle.

Parallelogram or Rectangle.

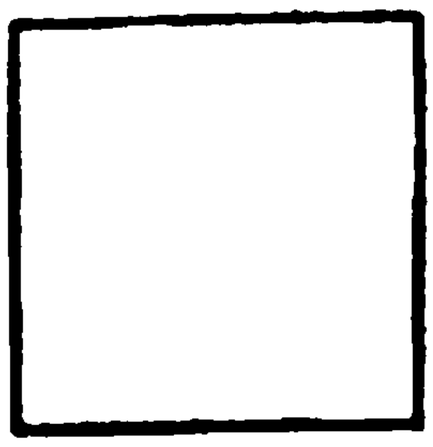


Trapezium.

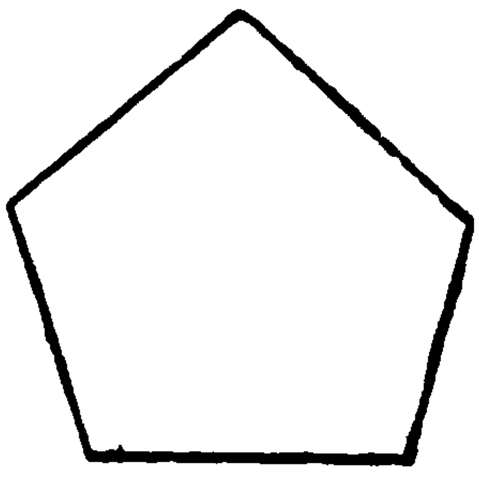


Rhomb.

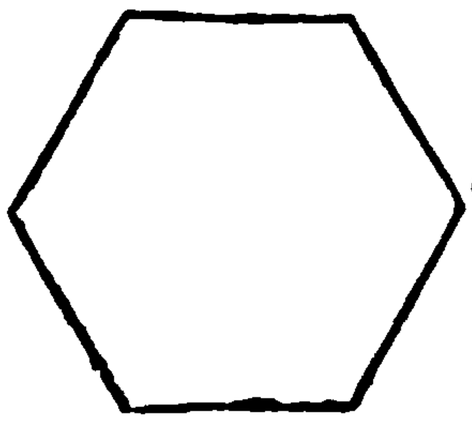
Rhomboid.



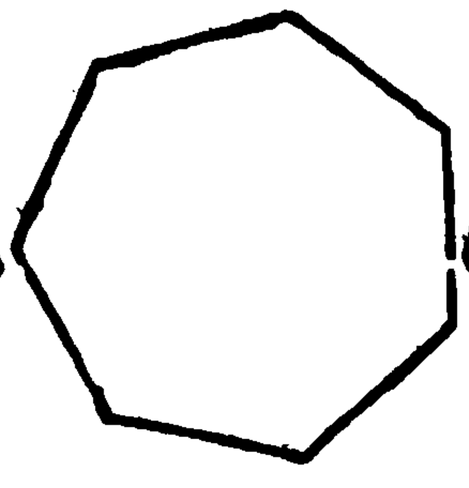
Square.



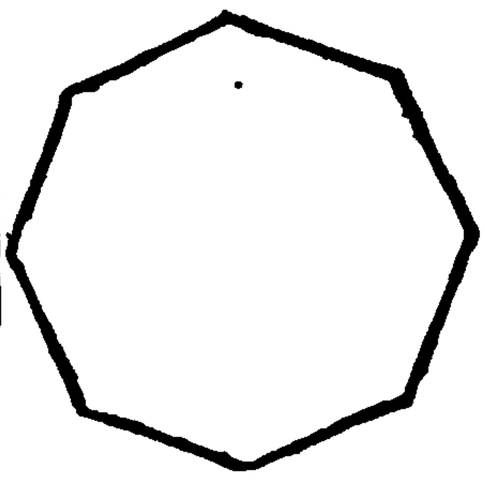
Pentagon



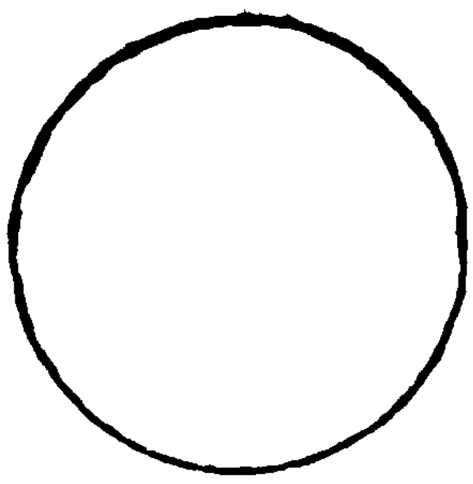
Hexagon.



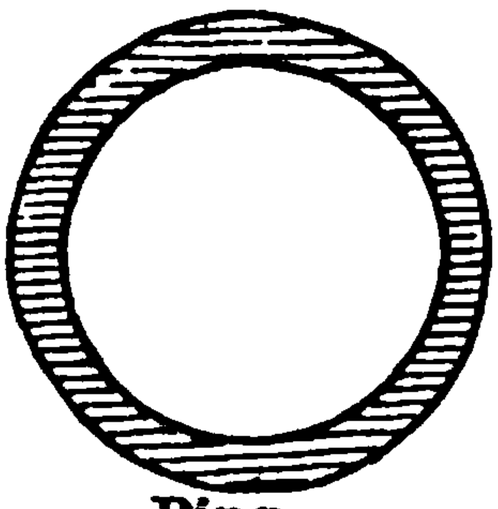
Heptagon.



Octagon.

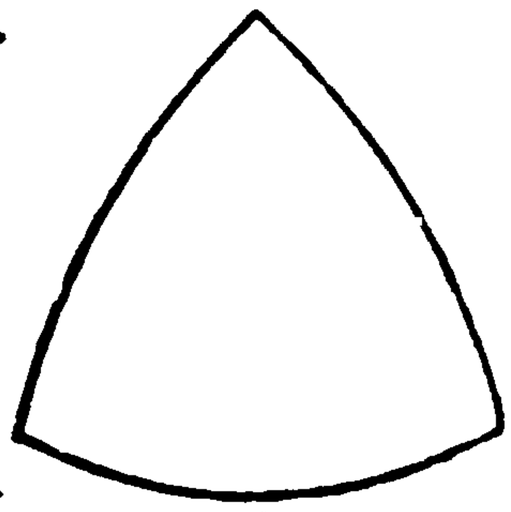


Circle.

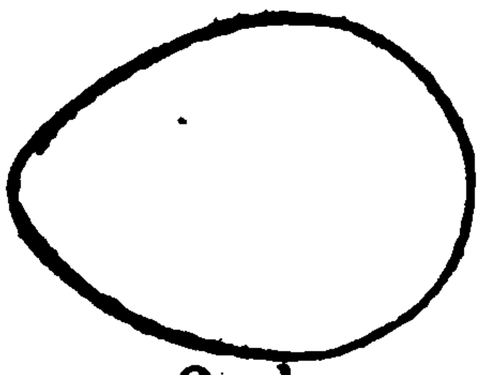


Ring.

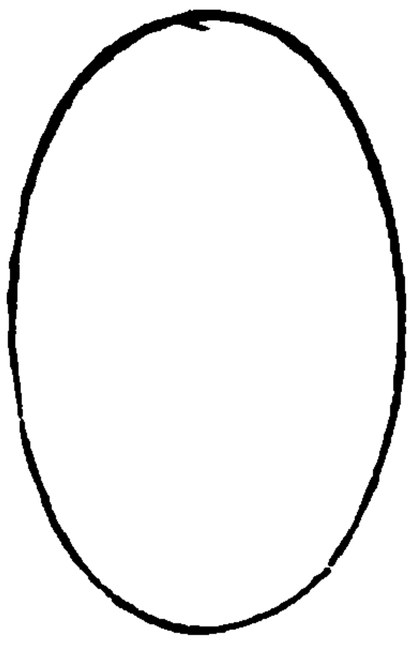
Crescent.



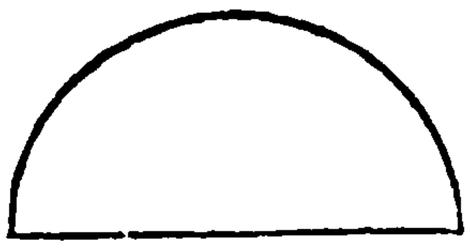
Spherical Triangle.



Oval.

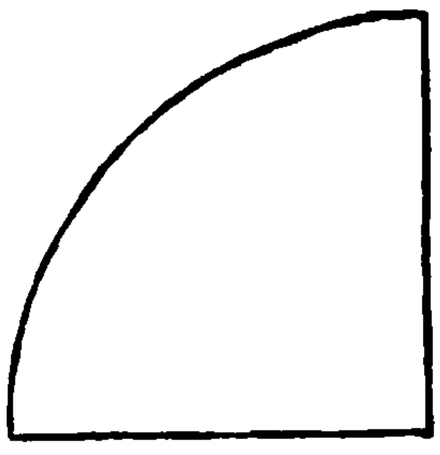


Ellipse,

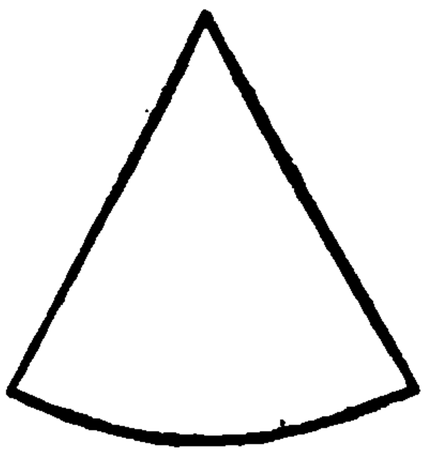


Semi-circle.

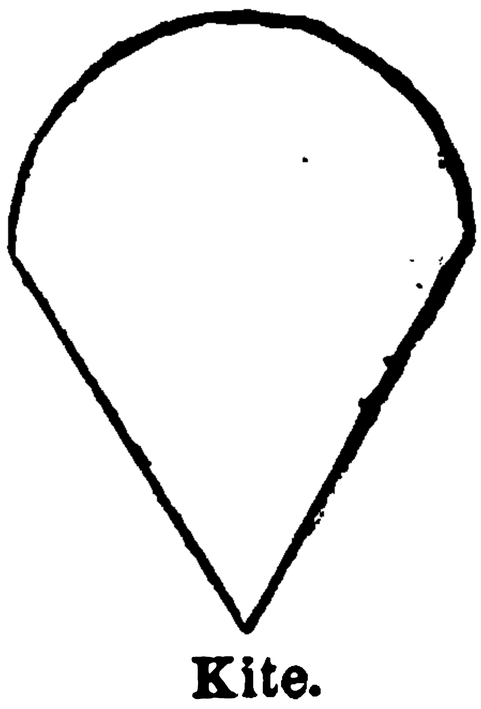
Segment.



Quadrant.

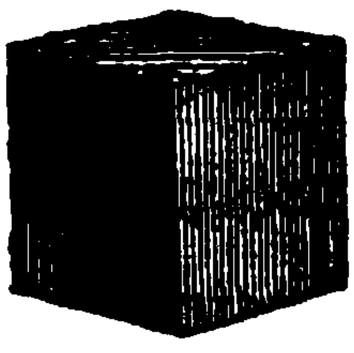


Sector.

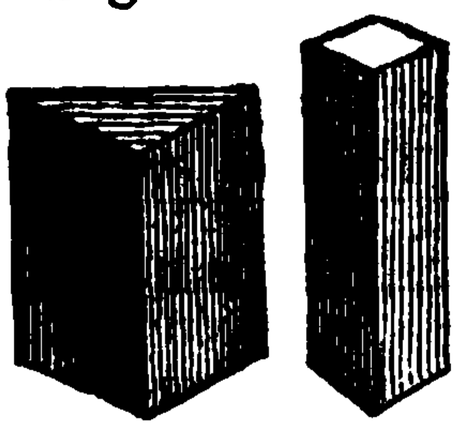


Kite.

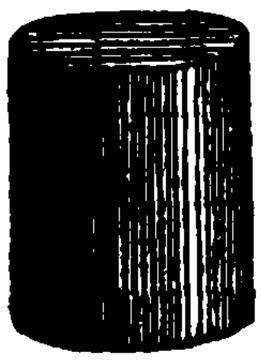
SOLIDS.



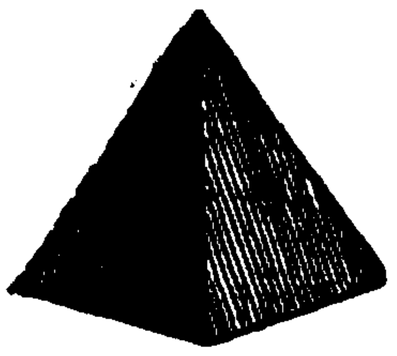
Cube.



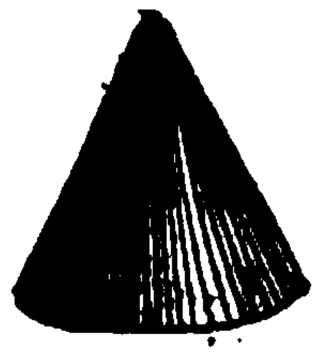
Prisms.



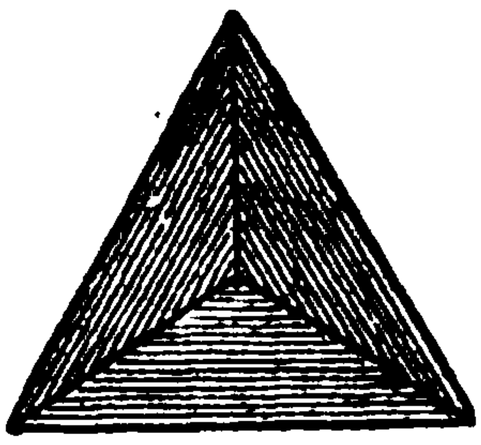
Cylinder.



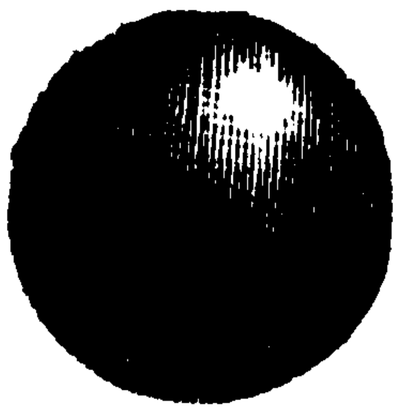
Pyramid.



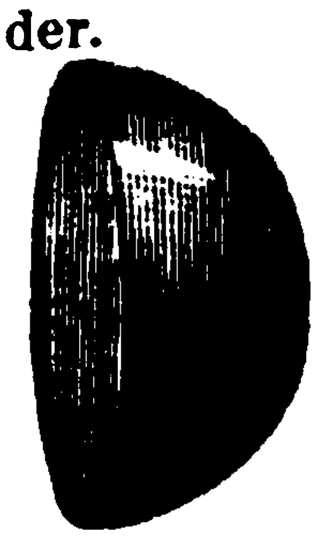
Cone.



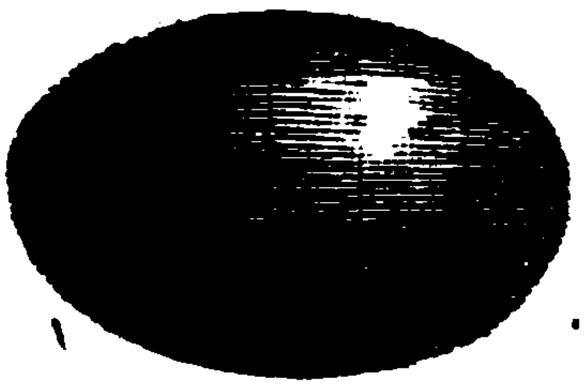
Tetrahedron.



Sphere.



Hemisphere.



Spheroid.

Methods of using these forms are given in Calkins' "Primary Object Lessons,"—Price $1.00
Model Lessons for Infant Schools, 3 vols., - - - - - - - - " 2.50
The whole subject of Primary School Training is treated of in
Barnard's Object-Teaching, Oral Lessons, and Methods for Primary Schools, " 1.50

OBJECT-TEACHING FORMS.

THE following pages furnish some sample lessons to illustrate methods of using these forms, and the Geometrical Solids in a Primary School. The teacher can use other pieces similarly. To those lessons we refer the reader, and only preface them with a few suggestions.

1. Distinguish and Classify.

a. Let pupils select all the forms made by straight lines—i. e., having straight edges,—omitting the solids.

b. Select all those having curved edges, or made by curved lines.

c. Select all made by a combination of straight and curved lines.

d. Select all three-sided figures. Notice the number of corners each has. In the same manner classify all four-sided figures, then the five-sided, and so on ;—noticing the number of corners each has—and that the sides and corners agree in number.

e. In like manner group figures made by one curved line; by two curved lines; by three curved lines; by one curved and one straight line; one curved and two straight lines, &c., noticing corners and peculiarities of each.

In this the teacher should guide and direct, but should allow the children to *do all the work*, thus securing their active interest.

2. Compare and Measure.

a. The teacher takes one triangle and calls on pupils to select all there are *just like it*, they judging by the eye.

b. Each pupil measures the one he selects by the one the teacher holds.

c. Successful pupils point out a similar figure on a card of forms—and draw similar ones on the blackboard.

d. The same process may be pursued with each of the triangles, and in future lessons, with the four-sided, and every other class of forms.

e. Let pupils select such pieces as are made up of two others, as the square made of the two right-angled-triangles; the rhomb, made of two equilateral triangles; the rhomboid, made of two rhombs; the trapezium, made of two large right-angled-triangles; the parallelogram, made of two squares; the circle made of two semicircles; and these again made of two quad-

rants, &c., &c. This will prove as instructive as it will be interesting.

3. Describe and Name.

a. The teacher calls attention to the distinguishing features of one form, and draws from the pupils a name which he accepts as *good*—but substitutes the common name as more convenient, or more commonly used.

b. After this, the form is to be spoken of by its proper name. When a mistake is made, the class correct, until the name becomes familiar.

c. Pupils should be taught to *describe* a form when its name is mentioned by the teacher.

4. Imitate and Invent.

a. For an exercise at their seats pupils should be required to draw on their slates one or more forms which have been the subject of the day's lesson, and to preserve a certain number of such drawings to show at the next class-exercise. They may be encouraged to make outlines of all familiar objects which are similar in shape.

Those who succeed best on their slates, may be sent to draw on the board, as a token of approbation.

b. Pupils may make on their slates all the figures they can invent, by using only a *certain number* of straight lines which the teacher names.

Another day, use a certain number of curved lines—then of straight and curved. After a few such exercises, it must be an *essential* that the forms thus made have some meaning, either by resembling some known object, or by having some elements of use or beauty.

LESSONS ON OBJECTS.

FORMS, ANGLES, SIDES, TRIANGLES.

APPARATUS—*Holbrook's Object-Teaching Forms.*

Teacher. Here is a box of thin blocks of different shapes, or *forms* as we will call them. Look at this form and tell me how many *corners* it has.

Pupils. "It has three corners."

T. How many sides has it? P. "Three sides."

T. Find all the blocks, or forms in this box, which have just three corners and three straight sides. How many are there?

T. Are they all alike? Then put all which are alike together and tell me how many *kinds* there are.

T. And how many forms of each kind? "Two of each kind."

T. The corners we will call *angles*. Then how many *angles* has each of these forms? "Three angles."

T. Forms which have *three* angles are called *tri-angles*—because *tri* means three. What then will you call all these blocks? "Triangles." Why?

T. Now will you take this second kind of forms (*right-angled-triangles*) and see if the corners, or angles, are all alike? Which then is the largest? Which is the smallest? Measure them by placing one form upon the other, and see if one angle is really larger than the others.

T. Now place these two forms together so the two largest angles shall touch each other, and the two forms shall be like one long piece. Do you see that the two long sides of the two large angles make one straight line?

T. Now change one of the forms so that the two largest angles shall still touch each other, but one long side and one short side shall be together at the bottom. Do these sides make one straight line? "They do."

T. Now place the forms so that one of the *smaller* angles shall touch the largest angle of the other form, and see whether the two lower sides make one straight line. "They do not, but make *two* straight lines."

T. Try all the other angles and see if you find any two angles which will fit together so as to have the two sides in one straight line.

T. I will now give you a name for the two large angles. They are to be called *right angles.*

T. Do you know how to tell whether an angle is a *right* angle or not? "Yes, *when it is so large that two such will fit together so that their lower sides make one straight line, it is a right angle.*"

T. Right. Now John may fit together all these *three-sided* forms, or—"*triangles*,"—on the table, and the class may call out right angle whenever he finds one. Remember how many right angles there are in all these pieces.

T. (*After all the corners of all the pieces have been tried.*) How many right angles have you found?

T. Which pieces have right angles?

T. Place these pieces together. Now, see if any of these forms has *more than one* right angle. (*Pupils examine.*)

T. What do we call all three cornered forms? "Triangles."

T. How do *these* triangles differ from all the others? "These all have one right angle, but the others have none."

T. Then how may I name these so you can tell them from the others, when I speak of them? "Call them triangles with one right angle."

T. Yes, but that is a very long name. Suppose I call them *right-angled-triangles*, will you know them by that name? "Yes."

T. Then we will call them so, because it is a good name, and is what everybody else calls them. What is the name? Repeat it all together.

T. Now, Mary and Lucy may measure the other angles by the right angle and see whether they are larger or smaller than it. The class will watch them and see whether they do it correctly.

T. (*When this is done.*) Lucy how do you find them? "All smaller than the right angle."

T. Do they have a *blunter* point than the right angle? "No, they have a sharper point."

T. Then what might we call all angles which are smaller than right angles? "Sharp pointed angles."

T. Yes, and you would always know that this means—what? "An angle *smaller* than a right angle."

T. Correct. But I will give you another name which means the same as sharp pointed. It is *acute.* Which name do you like best? Why?

T. Yes, it is shorter, and other people use this name, so we will. What then is our name for them? "Acute angles."

T. And *what* are *acute angles*? "*Angles smaller than right angles.*"

T. Who remembers what a right angle is? "*A right angle is an angle so large that when two of them are placed together, their lower sides make one straight line.*"

T. Who has found an angle larger than a right angle? Charles and Grace may measure all the four-sided pieces in this box and see if they can find any large angles. The class will watch them closely.

T. Charles, what do you find? "Four four-sided forms which have four angles, but they are every one right angles."

T. Very well, place those forms together, and we will see what Grace has to show us? "I find four four-sided forms, each having two angles larger than a right angle, and two more smaller than a right angle. Then here are two other four-sided forms which have each two right angles, and one angle larger, and one smaller than a right angle."

T. Ah, those are the very pieces we wish. Now Grace, show us the two right angles. Now the other angle which we know. What is its name? "*Acute angle.*" Which means —? "Sharp pointed."

T. Yes, and now show us the large angle. Why, how *sharp pointed* that is! "No, not sharp pointed, but *blunt* pointed, I should think."

T. How many think Henry is *wrong*? None of you!! Then how many think *I* am *right*? What, nobody!! How is it then? Sarah, please explain. "I think Henry is right and you are wrong." How many think as Sarah does?

T. Well, it seems the *angle* is blunt, but Henry and all the class are sharp.—Who now can tell us a better name for this angle than blunt-pointed? Then I will tell you a name which means the same, but is shorter, and is the one that other people use. It is *obtuse*. All repeat it. Now, what are *obtuse* angles? "*Angles larger than right angles.*"

T. How many kinds of angles have we now found? Lucy may tell, and give their names.

T. Henry may tell what a *right angle* is.

T. Mary may tell what an *acute angle* is.

T. Grace may tell what an *obtuse angle* is.

T. Charles may tell what a *triangle* is.

T. John may tell what a *right-angled-triangle* is.

T. You may each make on your slates all these angles and triangles, and bring them to the class at the next lesson. Be sure to make the lines straight and nice.

LESSON ON OBJECTS.*

PRISMS AND PYRAMIDS.

APPARATUS—*Holbrook's Forms for Object-Teaching.*

Teacher. How many objects have we here?
Pupils. Three.

T. What kind of objects are they? P. Solids.

T. Are they all alike? Do they differ in *shape* or in height. Are they made of the same substance?

T. Have all the same number of sides or *faces?* How many sides has this one? Three. How many has this one? Four. And how many has that one? Six sides or faces.

T. How many ends has each? Are both ends of each solid alike?

T. What shape are the sides of these solids? Parallelograms.

T. What is a parallelogram? A four sided figure whose opposite sides are equal and parallel.

T. What shape are the ends? They are of different shapes.

T. What does the shape of the end depend upon? Upon the number of the sides.

T. By what faces are these solids bounded? By parallelograms and by two ends. And how many sides have the two ends? As many as there are parallelograms.

T. I will now give you the name of these solids. They are called PRISMS. Spell prism. Write it on your slates. Pronounce it all together.

T. Now tell me how a prism is bounded. *A prism is bounded by parallelograms, and two ends which have as many sides as there are parallelograms.*

T. Repeat this together. Now what is the shape of the ends of this prism? A triangle.

T. Then we will call it a *Triangular* prism. What is the shape of the ends of this one? A square.

T. Then we will call this a *square* prism. Another name for it is rectangular,—or right angled prism, because the angles of the ends are all right angles.

T. How many sides or angles have the ends of *this* prism? Six. A six sided figure is called a Hexagon, and this prism is named a hexagon-al, or *hexagonal* prism.

T. Can there be other prisms besides these? There can be such as *pentagonal*, or five sided prisms; *heptagonal*, or seven

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* Miss Mayo's excellent Lessons on Objects is mailed, prepaid, for $1.35.

sided prisms; *octagonal*, or eight sided prisms; and *polygonal*, or many sided prisms.

T. Draw on the slate the shape of the end of this prism the triangular—now of this—the rectangular—and of this one, &c.

T. I will now show you another solid—a *pyramid*—and wish you to tell me whether this is a prism.

P. It is not.

T. Why not? P. Because it has only one end—while prisms have two ends.

T. Isn't this an end? What is it? A point.

T. Did you ever see anything that had not two ends? What? A sphere.

T. Who has another reason why this is not a prism?

P. Its sides are not parallelograms.

T. What are they? Triangles.

T. Are not triangles and parallelograms alike? Draw a Triangle on your slates. Show me the slates. Now draw a parallelogram. Are they not both alike? Show me the slates. Yes, they are different, but *how* are they different?

T. You have proved that triangles and parallelograms are different, now which of them bound a prism? Parallelograms. And what bound this solid? Triangles.

T. This solid is called a *pyramid*. Pronounce pyramid. Spell it. Write it on the slate. Who can draw a pyramid on the board.

T. Would a prism whittled to a point at one end be a prism still? What would it be? A Pyramid. Then we could make as many kinds of pyramids as of prisms. What kinds of prisms are there? Triangular, square or rectangular, pentagonal or five sided, hexagonal or six sided, heptagonal or seven sided, octagonal or eight sided and polygonal or many sided. Then what kind of pyramids can there be?

T. How can you tell the name of a pyramid? By counting the number of its sides.

T. You may draw on your slates the ends of the different kinds of prisms and pyramids and bring them to the class at the next recitation. All who can may also draw a picture of a prism and of a pyramid. You will find some pictures of these on the sides of your slates.*

Some interest will be given to this lesson by a description of the Pyramids of Egypt. Also, by asking for reasons why the pyramidal form is useful for towers, steeples, &c.

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*It is supposed that all the pupils will have the New York or Boston Primary Drawing Slate.

LESSON ON OBJECTS.*

SPHERE, CUBE, CYLINDER, CONE.

APPARATUS—*Holbrook's Object-Teaching Forms.*

Teacher. How many objects have I placed before you?

Pupils. Four.

T. Are they all alike? Are they different in *shape* or in *size?* Are they made of the same substance?

Repeat their names after me. Sphere, cube, cylinder, cone.

Tell the name of each as I point to it. Who can point out the sphere? Right. Now look at it and see if it has a flat side.

P. No. It has only one curved surface.

T. Is it the same in every part? If the surface were not the same in every part, would it be a sphere? Repeat with me, "A sphere has one curved surface everywhere the same."

What part of it do you see, the inside or the outside? What is the outside called? What is the middle of a solid called? What things have you seen of this shape? If a ball or marble were not exactly a sphere, would it roll evenly? What, then, is the best form for a ball or marble? Do you know that the earth on which we live, and the sun and the moon, are like this ball in shape? Now tell me what part of the earth you live on. If you live down in a coal mine, would you live on the *surface* then?

T. Which of these two solids will stand where it is placed, the sphere or the cube? Why?

Do you know what an edge is? Two sides must meet to form an edge. Some edges are sharp, some square, and some blunt.

Has the sphere edges? Will one of you come and point to a side of the cube? What shape is the side? Are all the sides of a cube alike? Where *three* sides meet they form a corner or solid angle. Who will show me a corner of the cube? Who will come and count the sides of the cube? You see they are all flat and square. Repeat, six flat, square sides. Now count the corners, or solid angles. Three plane angles meet to form one solid angle, and three edges as well as three sides meet in each solid angle or corner. Repeat, eight solid angles or corners in a cube.

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* Barnard's "Object-Teaching" is mailed for $1.50.
Calkins' "Primary Object Lessons" is mailed for $1.00.

Now count the edges; pass your finger along each edge. Say twelve straight edges.

Repeat the parts of the cube again; six square sides, eight solid angles, twelve edges.

Now, tell me the parts of the sphere.

P. One curved surface, everywhere the same.

T. Name all the things you can which are like a sphere. Now those like a cube. Show me the edges and corners of this box; now, the surfaces. Can I roll the box along? Why not?

P. Because it has flat sides.

T. Can I roll the ball? Why?

P. Because its surface is curved.

T. What figure is this?

P. A cone.

T. Will it stand? Why?

P. Because it has one flat side.

T. What shape is the part on which it rests? What is the part called? It is circular, like a circle—in shape, and is called the base. Repeat, a cone has a flat circular base.

How many surfaces do you see besides the base? Is it flat or curved? What does it end in at the top? Say, a cone has one curved side ending in a point? Has it any edges?

Now, repeat the names of the parts of the cone as I point to them; one flat circular base, one circular edge, one curved side, one point.

T. Who will find me the cylinder? Has it one end or two? What shape are they? Repeat two circular flat ends.

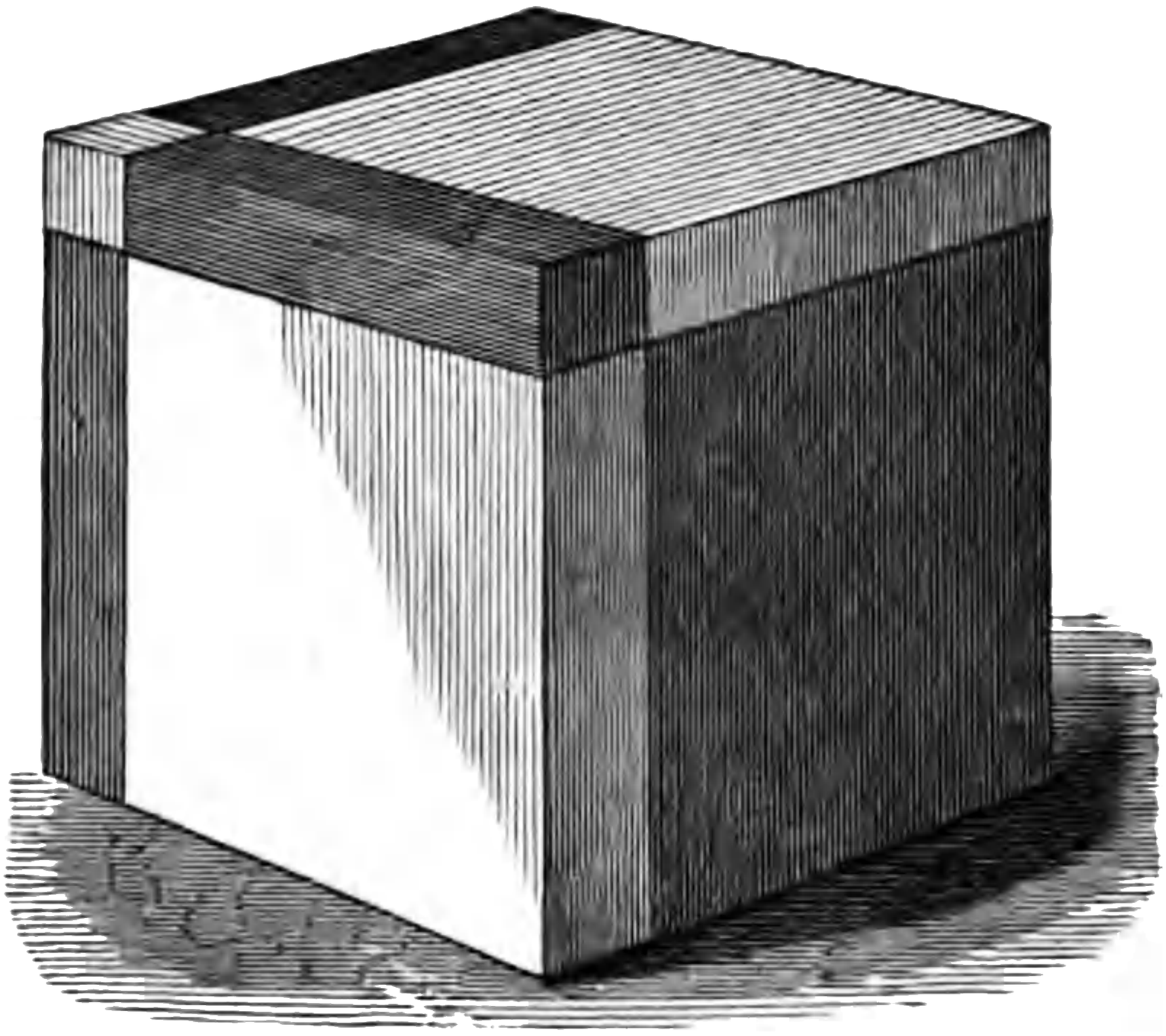
How many curved surfaces has it? Say, one circular curved surface. What have you ever seen of this shape? Are the bandbox and the drum solid? You have mentioned a column, a pole, a roller, as like a cylinder; are they solid or hollow?

Is the cylinder a good shape to roll along? Will a cone roll along? No; you see it will only roll round in a circle. Which of these solids is shaped most like the stem of a tree? Which like an orange? Which like this room? Which like a sugar loaf?

These questions should be much extended, and reversed; as, What is shaped like a cylinder, cone, &c.? The advantage gained by learning first the regular geometric figures, is the accuracy and certainty which it gives the learner; but whatever the lesson may be in which *objects* are used, their forms should be analyzed.

IV. CUBE ROOT BLOCK.

FIG. 11.



The extraction of the cube root can be explained most easily by the use of the Cube Root Block. In fact, no person who is unacquainted with Algebra or Geometry can know the reason for this rule without the aid of some such illustration.

An example will be given below as the exercise would be conducted with a class of pupils, who must be supposed fully prepared to commence this part of Arithmetic. The rule is in italics.

The number given by the teacher is 704969. Let each pupil place it on his slate, one doing the same on the blackboard. The first part of the rule reads,—

1. "*Separate the figures into periods of three figures*

each, beginning at units." Every pupil does this. The reason to be given is that "the cube of any *figure* cannot contain more than three figures, nor but two less." Hence, separating the number into periods will show the number of figures the root will contain, and will also enable us to find part of it at a time.

2. "*Find the greatest cube in the first left hand period.*" Having previously become familiar with this process, it needs no explanation. The required cube is 512.

3. "*Place the root* (8) *of this cube as the first figure of the root of the whole number, and subtract the cube itself* (512) *from the first period* (704.) This cube (512) is represented by the central block, which would contain 512 solid feet, and the root of the cube (8) is the length of one side of the block. It is plain that the cube root of the first period is now extracted, and the remainder should be joined to the next period: hence,—

4. "*To the remainder* (192) *bring down the next period*" (969), making 192969. We do not wish to find the *cube root* of this number, but to find *how thick a covering* can be made from it for the cube already found, i. e., the central block. We can cover it *entirely*, or cover only *half* of it; and, in either case, it will remain a cube. It is more convenient to consider the coverings (or additions) as placed on three sides, or half of it. To find the thickness of these additions, we have only to divide the number of feet to be added (192969) by the amount of surface on which it is to be placed. As it is to be placed on three equal sides, we first must find the surface of one side. The surface of any rectangle is found by multiplying the length by the breadth.

The length of one side of the central block, as already found, is 8 feet. But, the 969 is the second period, and the (192) remainder of the first period is put with it and all considered as belonging to the second period: hence, we must make the 8 of the root of the second period also. Adding one figure to the root has the same effect as adding one *period* to the number whose root is to be extracted. Hence, we call the 8, eight "ten's," or eighty, and the length of one side of the central block is to be estimated as 80 feet.

5. "*Square the root already found, regarding its local value ;*" i. e., multiply the length of one side, (80 feet,) by the breadth, (80 feet.) This gives the surface of *one* side of the central block, viz.: 6400 feet.

6. "*Multiply this square by* 3, *for a divisor,*" (because the additions are to be made on three sides, making 19200 feet of surface,) *by which divide the dividend,* (192969,) *and place the quotient as the second figure of the root.*" This figure, (9,) will represent the *thickness* of the additions. The example now is in this form;

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          704'969(89
          512
        ------
19200)  192969
          172800
        --------
           20169
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which is represented by the central block with additions on three sides. By the example there yet remains 20169 feet to be added. The blocks also show that the cube is not complete. Three corners need to be filled. These must have additions of the same thickness as the side additions, (9 feet,) and of the same length as the central block, (80 feet.) Hence, to find the contents of the corner additions:

7. "*Multiply the square of the last figure of this root,*" (9^2=81, which is the area of one end of a corner block,) "*by the first figure of the root,* (8,) *according to its local value,* (80,) (which gives the *contents* of one corner block,) *and multiply this result by* 3," (because there are three such corner blocks.) The result is 19440.

8. "*Subtract this from the previous remainder.*" There yet remains 729 feet. The blocks will now show that a small cube is needed in one corner, to make it complete. This must be the same in thickness as the additions, viz.: 9 feet. Hence,

9. "*Cube the last figure of the root, and subtract this from the remainder.*"

The Cube root is now extracted, and the blocks form a perfect cube, represented by the original figures, 704,969, while the length of one side of the cube (89,) represents the root. If more than two periods of figures are given, the process is the same as already described, commencing with the fourth step of the operation.

The DOUBLE Cube Root Block is highly valued for carrying on the illustration to three or more periods of figures.

V. GEOGRAPHY.

Though much difference of opinion has existed among teachers, it is now generally conceded that the study of Geography should commence in Primary Schools, with familiar conversations about the school-house and adjacent houses, streets, and lands; the localities being shown by means of a map made at the time, by starting from the school-room and locating surrounding objects as fast as

the pupils name them, thus making a map of the village, following this by maps of the town, county, and lastly of the State. The pupils will find employment in making and extending similar maps on their slates, and in classifying the productions, animals, minerals, curiosities, &c., &c., found within the territory embraced in their maps, for mention at their next exercise. Having thus learned the meaning of a map, they easily become familiar with larger ones, and in proper time are able to comprehend the design, so far as location is concerned, of the Map of the World. Just here the teacher finds the globe necessary to give any correct idea of the shape of the earth, and the relative position of the different countries. Without this aid his previous teaching can not be gathered into a compact form, and presented to his pupils as a "whole *round* earth;" but *their* earth will be a series of extended plains.

The globe should be constantly before the child's eye, from his first exercises in geography. In his studies, particularly in the study of history, he should locate on it all the places of which he learns. It should have a place in every Reading Room Library, and in the family, and should be referred to in connection with the daily newspaper, to show *where* the events described took place.

All know how difficult it is for many mature minds to think of the earth as *round*, or to have any clear idea of where the Savior lived, where Alexander reigned, or where the garden of Eden was situated. The use of the globe, for reference, will form correct impressions in the young, and will remove erroneous ones, where already existing.

VI. TERRESTRIAL GLOBE.

FIG. 12.

The globe represented in this cut is strongly made, of firm material, and so mounted on a simple pedestal that it can be readily removed and suspended by a cord, and thus be more conveniently used for many illustrations, with a class, than if mounted in the usual manner. It is suitable in size, (5 inch,) for common use in the school-room, as it can be easily held in the hand, or passed round the class, and yet answers all the main purposes of the larger sized globes. There are twenty-four meridians; hence, the difference in time is easily reckoned, being one hour for each meridian on this globe. The outlines of the conti-

nents are strongly marked, that the countries may be clearly

distinguished by an entire class, though at some distance from it. This feature has been considered more desirable than minuteness of detail or delicacy of coloring. It is made cheap, hoping thus to hasten the time when *every school* will have a globe. Larger globes, 8, 10, 12 inches, and 24 inches in diameter, can be supplied when wanted, and should be in all higher schools. Shall they not find a place in Reading Rooms and Family Libraries? Globes and Maps mutually aid each other; and schools or teachers supplied with these and similar articles, have their facilities for imparting instruction proportionately increased. Many of the advantages of Academies are the result of their facilities for illustration. (For illustrations by the globe, see Part II. and Contents.

HOLBROOK'S EIGHT INCH TERRESTRIAL GLOBE, No. 18a, (see cut,) possesses the following advantages over others, viz.:

1. The water is colored a *dark blue*, which, besides being more natural than white, shows the land more distinctly, and makes it appear elevated above the level of the water. A globe of this color does not soil and look *old* nearly so soon as a white one.

2. The OCEAN CURRENTS are shown, and aid much in teaching Physical Geography. This is valuable for every grade of schools.

3. The Meridian is stationary, and by a new and ingenious arrangement the *globe is movable in the meridian*, enabling us to elevate or depress the pole at pleasure to any extent. The degrees on the fixed meridian indicate its elevation.

HOLBROOK'S EIGHT INCH GLOBE.

No. 18a.

SHOWING THE SOUTH POLE.

4. The *horizon may be removed*, and may also be used as a Day and Night Circle to illustrate the change of seasons. This is a new feature, and with the new mounting in the meridian, gives a facility for, and extent of illustrations not afforded by any other globe. The entire arrangement favors the natural method of teaching.

5. The mounting is all brass, making a beautiful and well finished globe. In some of its several styles of mounting it will suit every school, and at a trifling cost. It is *complete* to the present time, and in short, corresponds with our motto, "Good enough for the best and cheap enough for the poorest."

A copy of our Globe Manual will accompany each globe.

This globe is mounted in three styles, viz.:

No. 18a. As shown in the cut, complete, with horizon and quadrant.

No. 18. The same as No. 18a, but without horizon or quadrant.

No. 17. On simple wood stand with inclined axis like figure 12 on preceding page.

Prices are given on page 19.

VII. HEMISPHERE GLOBE

FIG. 13.

When pupils have become familiarized with the fact that the earth is round, like the globe, they can not recon cile the impressions given on the maps with those given by the globe. The map of the world shows two North and two South poles, the globe *only one* of each; and the globe is the acknowledged standard. The map shows curved lines; on the globe all lines are straight. On the map, a part of Asia is far separated from the rest, but the globe represents Asia as a whole; while the Pacific islands which, on the globe, lie near each other, on the map appear at different sides of the earth. The mind of the child asks, why these differences. And teachers know, by wearisome experience, how difficult it is to reconcile such impressions. Some teacher, putting into practice a happy suggestion, invented the Hemisphere Globe, which affords a most complete solution of such knotty problems.

On its exterior surface is the globular map, or globe representations, and on the interior, the plane map, or map of the World.

1. If this is opened and removed across an ordinary room, with the globular surface presented to the eye, it will appear flat. Let the children understand that the maps are drawn as if seen by the eye at such a distance that the round surface of the earth would appear flat.

2. Again, show the class one of the hemispheres on the outer surface; let them imagine it elastic and capable of being pressed flat; then, opening the globe, present the plane surface it would assume if flattened, i. e., the same hemisphere in the map. They will readily see that the lines must assume the circular form, and must approach nearer each other in the center, thus making the parallels of latitude widest at the circumference of the map.

3. Or, present the map side and show the *four* poles; close the globe and it will at once be seen how the four poles arise from two, only. Likewise, those parts of Asia, and the Pacific islands, so far separated, will be seen to be really joined and the map representation to be a correct one, *when correctly understood.**

As the pupils advance in years and attainments, the conversational method of teaching geography must be changed to one requiring more actual study by the pupil. The principal object sought should be to fix in the mind

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* Mr. Richard G. Parker, of Boston, is believed to have made and used the first Hemisphere Globe, in 1827.

of the scholars the form and localities of the various divisions of land and water, giving comparatively little descriptive geography to be learned.

For this purpose the study of the map affords the best means. Maps should be copied with care and accuracy as a daily exercise, and at recitation or other times, some of the best ones may be placed on the blackboard, entirely from memory.

VIII. OUTLINE MAPS,

Should be used in recitation, and every place mentioned should be pointed out by a member of the class, as it is named. For study, the scholars should be provided with a text-book which is a key to the Outline Maps from which they are to recite, containing the same maps in miniature, with references to names of the various localities. Combine with this enough descriptive geography, *and not too much*, to give correct general ideas of the most important characteristics of countries and their inhabitants, and we have the *best* geographical system for pupils from 9 to 12 or 14 years of age.

The only maps known to the writer which unite *all* the requisites above mentioned, are MITCHELL'S OUTLINE MAPS, consisting of a set of ten, viz.:

No. 1. Hemispheres,	30	by	50	inches.	No. 6. Asia,	25 by 30	inches.
" 2. N. America,	25	"	30	"	" 7. Africa,	25 " 30	"
" 3. United States and Mexico,	50	"	60	"	" 8. Oceanica,	25 " 30	"
" 4. S. America,	25	"	30	"	" 9. British Prov.,	25 " 30	"
" 5. Europe,	50	"	60	"	" 10. Physical (the World,)	50 " 30	"

"These Maps, in connection with the Manual of Geography and Key, form a complete system from which a

thorough knowledge of geography can be acquired in much less time than is commonly devoted to the subject.

They are now used extensively, having been adopted in more than *ten thousand* schools throughout the country, and the system needs only to be sufficiently understood to become universal.

Price of the Maps and Key in a neat portfolio, $12.00."

The use of Outline Maps, by older pupils, is thus mentioned in the "Teacher Taught," by Emerson Davis.

"There is another method of teaching Geography to the elder scholars in a Common School, which interests them much, and renders the study very profitable. A large *outline* map, drawn upon cloth, is used; or, for want of maps, the outlines may be drawn upon the blackboard. The class is seated in front of the map; one of their number is designated to stand by it and mention the boundaries of a country, and with a rod to point to the rivers, mountains, and the place of the large towns, calling each by its name, and, in short, to tell all he knows respecting the geography of some State. If any member of the class can add anything, or would correct anything, he signifies it by raising the hand, and permission is granted. This is a very intellectual method of studying geography. If the teacher has any zeal, some of the class, if not all, will be inspired with a laudable ambition to know much respecting the lesson, and to acquire accurate information."

This mode is properly applicable to the study of geography by topics, (page 53.)

Allowing volunteers to point out places, rivers, mountains, lakes, &c., on the map and try to "puzzle" the class by calling for the names, or letting the class call for places to be pointed out, and thus puzzle the volunteer, will much increase the interest in the map exercises. No teacher should be without Outline Maps, for if his district is unwilling to provide them for the school, he *can make them himself*. This has been done in numerous instances.

IX. MAP DRAWING.

Probably the most effective means for making the knowledge gained from the map permanent, is by map drawing.

Besides the special object of *fixing* the knowledge in the mind, practice in drawing maps gives power over the hand, and ability to judge correctly by the eye, equally with linear drawing, and it is attractive to pupils.

Fowle's Teachers' Institute says,

"Children love to draw, and, although at first their work is very imperfect, the idea or picture in the mind is more correct than that on the slate, and practice will soon render the latter very exact, and the former almost indelible. Since the first Teachers' Institutes were held, the number of teachers who require their pupils to draw maps, has very greatly increased."

"But maps drawn on the slate and on the blackboard are soon erased, and are rarely drawn with so much care and accuracy as those done on paper. Let the children, therefore, immediately begin to draw on paper, also. In this exercise no instruments should be used but the eye, the fingers, and the pencil or pen. It is more important to train the eye and the hand, than to have a perfect drawing."

Pupils should be taught that maps are drawn on different scales of magnitude. If the map of their own village is made on the blackboard, and the teacher then proposes to make a map of the town on the same space, they will readily see that the village will occupy but a small part of this map. Then a map of the State may be drawn in the same space, when the map of the village will dwindle to a small square, or perhaps a dot.

When they commence the study of Geography from the text-book, let it form a part of each lesson to bring to the recitation a map of the State or section of which they are

learning. Too much must not be expected of them. Let the outlines be drawn the first day; this map may be preserved, and next day the mountains and rivers be added; another day, the towns, and so on until the map is complete. It is evident the map must be on paper for this purpose. Let all the maps be of the same size; for young scholars, one-eighth of a letter sheet will be a convenient form. They will draw more correctly on a small scale.

Some pupils who have a natural taste for drawing, will make very neat maps, at once; others will be disheartened by their want of success. To allow some of the most skillful to place their maps on the blackboard, *from memory*, during the class recitation, or afterwards, will exercise a good influence over all; but the *weak* ones need encouragement. They have labored, perhaps, more diligently and anxiously than the others. The teacher can not praise their *maps;* he may, however, commend their *efforts;* and if in addition to this, he will notice, without seeming to, where they have made mistakes, and then will himself draw an outline on the blackboard, making the same errors and *exaggerating* them, and will request the criticism of the class, he may find the very scholars criticising him, who have themselves made the same mistakes. After a criticism is given, he should explain how it may be corrected next time; then call the attention of each member of the class to his own map, to see whether he has made a similar error. The pupil should not be required to tell his failing, but he will see it, and it will *not* appear in his next map. One suggestion will be given in this connection, which may apply to other things as well as to map drawing, viz.: Call attention to excellencies;

show where and how improvements may be made; but DON'T FIND FAULT.

Those who have leisure time may be allowed to draw other maps and bring to the recitation, and for each *nice* one may receive a merit mark or other testimony of his teacher's approval.

Pupils should be taught a regular order of proceeding. First, draw the outlines with pencil; second, ink them if desired; third, shade the coast and color the map, if it is to be colored; fourth, draw rivers and mountains; fifth, locate the towns, with their names. This supposes the border of the map, with lines of latitude and longitude, to be prepared for the pupil; otherwise, that is the first step.

The shores may be shaded with pencil, making lines heavy at the shore, and lighter as they go from it, to represent the increasing depth of the water. These lines should *always be horizontal.*

Another method is, with India ink—where the maps are drawn with ink—and two brushes should be used. With one, draw a small portion of the coast, neatly, and while wet, take the other brush, wet but clean, and spread the ink from the shore outward. Do but a little at a time, for the ink must be spread before it dries.

A fine effect is produced by shading with pencil, in wave like lines, as engravers do in the Atlas. This requires patience and skill, but when well done is the best manner.

When familiar with the maps of the New England or Middle States, for example, the pupils may have an exercise like the following: Call on one scholar to draw, on the blackboard, from memory, the New England States, beginning with Vermont, and joining the other States in

their proper place; another, the same, beginning with Massachusetts; another, beginning with Rhode Island, and so on, each beginning at different points, and completing the outlines of one State at a time.

Especially should care be insisted on in drawing and preserving the maps; and if sheets of the best ones are suspended in the school-room, or preserved by the teacher, the pupils will be incited to greater effort, by seeing their labors appreciated.

A well known educational lecturer, and for many years a teacher,* says,

"Once a year it was my custom to let every pupil draw a map to be bound in a volume, and kept as a record of the ability of each, and as a landmark of the progress of the school, as a whole, in this branch of manual skill. I furnished to every pupil a piece of paper, of uniform size, and left it to her to draw what map she pleased, and to ornament it as her taste might dictate. I have preserved many such volumes, and they are to me precious memorials. * * * It often happens that the first and last map the pupil ever drew, is preserved in these volumes. * * * The outline, printed names, and coloring, are entirely their own, and their names and ages, written by themselves, are at the bottom of their maps."

A great saving of needless and *useless* labor is effected by procuring mapping plates, or skeleton maps, which have the lines of Latitude and Longitude, and the border of the map, prepared for the pupil. In some of our best schools, the parallels and meridians are placed on the blackboard, and the pupils are required to draw the map on a large scale, upon the board. The accuracy and neatness with which this is done, wholly from memory, never fail to delight all who see them. Such a recitation is far

* Wm. B. Fowle.

superior to merely answering questions. Some directions for this exercise are here given, from an article in Conn. Common School Journal, 1854, by J. W. Tuck, Principal of the Model Department of the Conn. Normal School:

"In giving my method, I will not now speak of teaching the rudiments, but will commence with the hypothesis that the learner is familiar with elementary geography, and has a correct and thorough knowledge of the earth's circles.

It will also be of great advantage if the pupil has had experience in map copying, on sheets of fine paper prepared for this purpose, (mapping plates.) This should be done with as great precision and excellence of finish as the scholar is able to attain, which will serve at once to discipline the eye, the hand, and the mind.

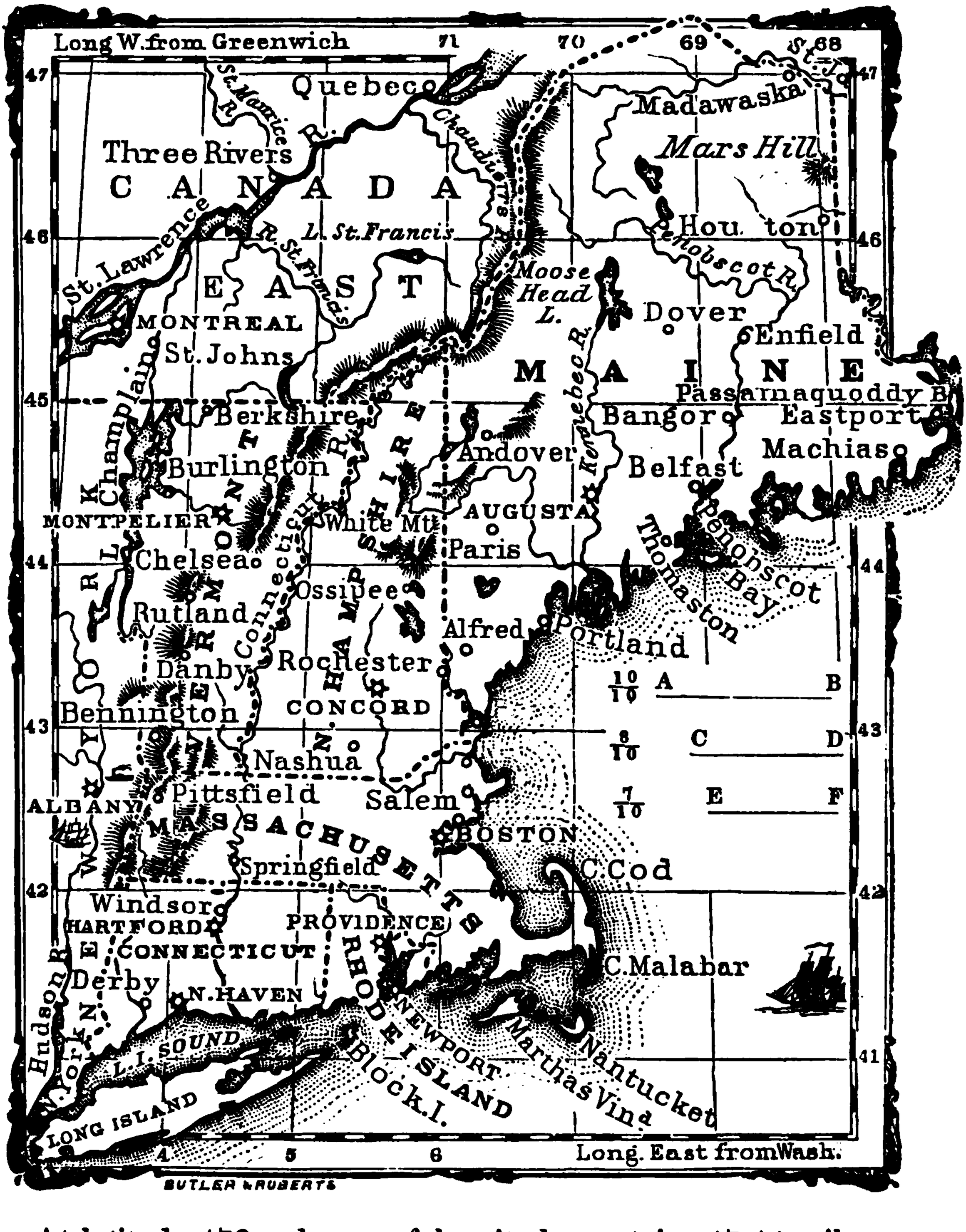
We will now, before proceeding farther, require the class to learn, rejecting the fractions, the number of English miles contained in a degree of latitude, also in a degree of longitude on every tenth parallel of latitude from the equator to the poles, and from this knowledge can be calculated the number of miles contained in a degree of longitude on any parallel of latitude. We are now prepared to 'lay out' the latitude and longitude, upon the blackboard, for a map of any given country. For illustration, we will take New England.

I find my skeleton map will extend from latitude 41° to 47° N.; and taking any space which the size of the blackboard will allow, as the distance between the parallels, or, which is the same thing, the length of a degree of latitude, I regard this distance as the unit by which to form the map.

Let the line A B, (fig. 14,) represent this unit, or $\frac{1}{6}$, which for the convenience of round numbers, we will regard as containing 70 English miles, for the number of miles in a degree of latitude, or in a degree of longitude at the equator. Now, having thus drawn the parallels of latitude, if I bisect them with a perpendicular line, it will denote the *center meridian* of the map. At latitude 41°, I find a degree of longitude contains but 52.16 English miles, or, which is accurate enough for my present purpose, a degree of longitude at this point is about $\frac{52}{70}$ or $\frac{8}{10}$ of a degree of latitude, and representing this distance by the line C D, we have the length of a degree of longitude at latitude 41°.

MAP OF NEW ENGLAND.*

FIG 14.



At latitude 47° a degree of longitude contains 47.44 miles; and, reasoning as before, it will readily be seen that at this point a degree of longitude is equal to $\frac{4}{7}\frac{7}{0}$ or about $\frac{7}{10}$ of a degree of latitude; hence we have the line E F. Starting

* Taken by permission from Smith's valuable PRIMARY GEOGRAPHY.

at the 'center meridian,' we place dots at a distance from each other denoted by the length of the line C D, upon the 41st parallel, and upon the 47th, dots at a distance denoted by the line E F. Knowing the longitude, we will proceed to number these dots respectively 68, 69, 70, 71, &c., upon the two different parallels. Having done this, we will next connect, by a line, the dots of corresponding numbers, which will give us the right meridians for this section of country, and a complete 'skeleton map' of New England, of sufficient mathematical correctnes for our purpose.

If it is thought proper to 'lay out' the latitude and longitude with greater accuracy than in the foregoing figure, it can be done by using *complex fractions*. However, with a little exercise of the judgment, the difference will hardly be perceptible in the use of chalk, (a chalk line) upon the blackboard.

The teacher can easily explain to the pupil why the 'center meridian' of the map is perpendicular, by resorting to a small globe, an orange, or a Hemisphere Globe.

Having now completed the skeleton, let a member of the class, for the *first* exercise, proceed to copy the outlines of Maine; then another member add the principal rivers, lakes, mountains, &c. These being finished, consider the class a 'Criticising Committee.' Perhaps the first criticism will be upon the latitude of a certain point; the second, upon the length of a river; and thus they will continue, the whole class becoming exceedingly interested and profited at the same time.

For the next lesson, require each member of the class to be prepared to construct the same map, *from memory*, upon the blackboard, and *always* from memory, except in the beginning. Each one should work as rapidly as possible, and as soon as all are ready, allow the 'Criticising Committee' again to open their battery upon the different results. After the 'proposed amendments have been discussed and adopted or rejected,' require some one to go to the board and locate the capital and principal towns, noticing, when upon rivers, whether they are situated upon the *right* or *left* bank. In a similar manner we can proceed, taking up, respectively, the departments of mathematical, topographical, physical, descriptive, civil, and statistical geography. After a little practice, one State in advance and one in review, will not be found too much for a lesson.

To allow the learner occasionally to project a map of nice execution, is of great advantage in cultivating correctness and good taste. Those who are disposed to adopt the method of

teaching geography, the principles of which are imperfectly described in this article, will find it has great merit, at least in giving clear ideas of the Great Circles, while it fixes distinctly in the mind a permanent knowledge of relative situations, directions, and natural features of the globe.

The purpose of the foregoing figure is more particularly to illustrate my manner of forming a skeleton map, and also to exhibit a specimen of rivers, lakes, coasts, and mountains as they should be represented with a pen upon paper, or upon the blackboard with chalk. All names should be omitted.

The most convenient Table I have ever seen, showing the number of miles in a degree of longitude on any parallel of latitude, is found in 'Mitchell's Geographical Question Book.'" (Also, see page 127.)

X. TOPICAL GEOGRAPHY.

"Being the most difficult, and requiring greater mental development than any other mode of pursuing the science, Topical Geography is properly reserved for the older pupils, and to complete this branch of study.

"This method takes for granted, not only a systematic arrangement of topics, by which to study any given country or political division, but a classified view of the entire subject matter of Geography; and it is further supposed that every teacher will make himself thoroughly acquanted with such a classification before he shall attempt to use the Topic System in his course of instruction.

"This general outline of the Science of Geography, in its different departments, can then be given in suitable portions on the blackboard, by the teacher, with definitions and explanations, and copied into note books by the scholars, who will afterwards, in succession, from day to day, present it *without notes* on the blackboard, *with* definitions and explanations, subject to the criticism of the class and the teachers.

"Two or more departments may be assigned to as many pupils for each day's recitation, until every scholar shall have given the whole satisfactorily. In order to economize time, one scholar, or the class at large, may be engaged in reciting the topics as applied to the country, previously assigned for a lesson, while two or more are writing their exercises on the blackboard.

"Outline Maps, a Globe and Tellurian, are indispensable for the highest success of the Topic System, as well as for thorough instruction by any method whatever.

"For the purpose of assisting teachers who may not otherwise be able to avail themselves of this system, a general outline of the science is here given, as well as a more definite arrangement by which to study the geography of any particular country, state, or kingdom.*

"It will be perceived that this method does not require a uniformity of text-books, but makes a diversity desirable, rather than otherwise.

"Further, the plan admits of almost endless variety in the course of procedure, giving ample scope for the ingenuity and skill of the teacher, in awakening and sustaining interest, and in imparting thorough and varied instruction."

GENERAL OUTLINE OF GEOGRAPHY.

1. Mathematical.
2. Physical.
3. Statistical.
4. Civil.

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* This plan—some additions and alterations having been made—was originally prepared by Mr. A. Holbrook, now Principal of one of the Normal Schools of Ohio, and is not excelled by any known to the author.

(Under these heads the topics designed for lessons to a class are printed on the left hand side of the page, and IN SMALL CAPITALS. The pages also contain an outline of the information to be given by the pupil as a recitation on each topic, and which will require illustration by pupils or teacher.)

I. MATHEMATICAL GEOGRAPHY.

1. POSITION OF THE EARTH.
- Third Planet in the Solar System.
- Distance from
  - Sun, 95 millions of miles.
  - Moon, 240 thousand.
  - Other Planets, variable.
  - Nearest Fixed Star, 60 trillions.

→ Illustrated by Orrery.

2. FORM.
- Proofs that the Earth is Spherical.
  1. Circumnavigation.
  2. Appearance of ship at sea.
  3. Shadow on the Moon.
  4. Appearance of Polar Star.
  5. Vertical and Horizontal Lines.
  6. Attraction.
  7. Analogy.
  8. Actual Measurement.
- Proofs that the Earth is an Oblate Spheroid.
  1. Varying Vibrations of Pendulum.
  2. Measurement of degree of latitude.
  3. Effect of Centrifugal Force.
  4. Analogy.

→ Illustrated by Globe Tellurian, and Celestial Sphere.

3. MAGNITUDE.
- Diameter.
  - Equatorial, 7,924
  - Polar, 7,898
  - Mean, 7,912

  → Difference, 26 miles.
- Circumference, 25,000
- Area, 197,000,000

  → Square miles.

4. MOTIONS AND VELOCITIES.
1. Diurnal—1,000 miles per hour at Equator.
2. Annual—68,000 " " in Orbit.
3. In common with the Solar System, 35,000 miles per hour.

→ Illustrated by Tellurian and Orrery.

5. LINES AND DIVISIONS.
1. Diameter.
2. Circumference.
3. Axis.
4. Equator.
5. Tropics.
6. Polar Circles.
7. Parallels of Latitude.
8. Meridians of Longitude.
9. Zones.
10. Hemispheres.

→ Measured by the Divisions of a Circle.
- Degrees.
- Minutes.
- Seconds.

→ Illustrated by Globe, Hemisp'ere Globe, and Maps.

6. METHODS of representing Shape, Surface, and Relations.
- Globe.
- Tellurian.
- Orrery.
- Maps and Charts.

7. PHENOMENA.
1. Day and Night.
2. Where a Day commences.
3. Difference of Time. (Absolute. Relative.)
4. No absolute UP and DOWN.
5. Change of Sun's declination.
6. Rising and setting of the Sun north of east and west, in summer.
7. Change of Seasons.
8. Eclipses.
9. Tides.
10. Changes of Moon.
11. Precession of Equinoxes.

→ Illustrated by Globe, Tellurian, and Celestial Sphere.

☞ For illustrations with Globe, Tellurian, &c., see Index under each article.

II. PHYSICAL GEOGRAPHY.

1. Structure. { Geology, Mineralogy, } Illustrated by Cabinet of Minerals.

2. Land.
- Divisions, { 1. Continents. 2. Islands. 3. Peninsulas. 4. Isthmuses. 5. Capes. 6. Promontories.
- Surface,
  - Mountains, { 1. Ranges. 2. Systems. 3. Groups. 4. Peaks. 5. Volcanoes, { Active. Dormant.
  - Hills, Valleys, Plains,
    - High, { Prairies in United States. Pampas in S. America
    - Low, { Pampas in S. America
    - Fertile, { Steppes in Asia
    - Barren, { Sandy. Salt

3. Water.
- Oceans and Seas considered in respect to { 1. Extent. 2. Depth. 3. Temperature. 4. Color. 5. Taste. 6. Motion. 7. Uses.
- Lakes, { Salt. Fresh. } { 1. With Inlets and Outlets. 2. " Inlets and no Outlets. 3. " Outlets and no Inlets. 4. " neither Inlets nor Outlets. 5. Subterranean. 6. Periodical.
- Gulfs and Bays.
- Straits.
- Rivers, etc., etc.

4. Climate.
- 1. Temperature.
- 2. Moisture.
- 3. Salubrity.
- 4. Circumstances modifying. { 1. Latitude. 2. Elevation. 3. Proximity to body of Water. 4. Aspect of Country. 5. Nature of Soil. 6. Degree of Cultivation. 7. Vicinity of Mountains. 8. Direction of Declivity. 9. Prevailing Winds.

5. Soil. { 1. Calcareous, 2. Silicious, 3. Aluminous, 4. Loamy, 5. Alluvial. } Fertile. / Sterile.

III. STATISTICAL GEOGRAPHY.

1. Population. { On a square mile. White. Colored, { Free. Slave.

2. Productions.
- Minerals. { Ores, Building Materials. Precious Stones. Fuel, etc. } Illustrated by Cabinet of Minerals.
- Vegetables. { Food, Building Materials. Fuel, Dye Stuffs. Ornamental Woods. Drugs and Medicines, etc.
- Animals.
  - Beasts, { Wild. Domestic.
  - Birds. Serpents. Insects. } Description of, and Varieties.

3. EXPORTS AND IMPORTS. { Materials, { Exported. / Imported. } { Why abundant. / Why deficient. }

4. OCCUPATIONS. { Agriculture. / Manufactures. / Commerce. / Literature. / Science. / Art. } Relative importance of each; Proportion of people engaged in each.

5. EDUCATION. { Public. / Private. } { Sectarian. / Secular. / Charitable. / Reformatory. }

6. MANNERS AND CUSTOMS. { Compare different nations, people of like civilization, in different zones; people in different stages of civilization, in same zone, &c.

7. CURIOSITIES. { Natural. / Artificial. }

IV. CIVIL GEOGRAPHY.

1. CIVIL DIVISIONS. { Empire, Kingdom, Republic, Duchy, etc., / State, County, Town, City, Village, etc.

2. RACES. { 1. Caucasian. / 2. Mongolian. / 3. Malay. / 4. American. / 5. African. } { Number, and locality. } of each. .....

3. STATE OF SOCIETY. { 1. Savage. / 2. Barbarous. / 3. Half Civilized. / 4. Civilized. / 5. Enlightened. }

4. RELIGION. { 1. Christians. { 1. Roman Catholic / 2. Greek Church. / 3. Protestants. / 4. Nestorians and Arminians. } / 2. Jews. / 3. Mahometan / 4. Pagans. }

5. GOVERNMENT. { 1. Patriarchal. / 2. Monarchy. { Absolute. / Limited. } / 3. Aristocracy. / 4. Democracy. { Pure. / Representative..... }

Countries where each prevails.

V. ARRANGEMENT OF TOPICS FOR THE STUDY OF ANY COUNTRY, STATE, OR KINGDOM.

1. Boundaries?
2. Latitude and Longitude?
3. Surface?
4. Mountains?
5. Plains?
6. Islands?
7. Capes?
8. Bodies of Water?
9. Rivers?
10. Climate?
11. Soil?
12. Natural Curiosities?
13. *Productions?*
14. *Exports and Imports?*
15. Square Miles?
16. Population?
17. Race?
18. State of Society?
19. Capital?
20. Chief Towns?
21. Internal Improvements?
22. Education?
23. Religion?
24. Government?
25. Manners and Customs?
26. Language?
27. History?
28. Science, Literature, Arts?

These topics, arranged or combined in any order the teacher may prefer, can be taken separately as a lesson for the entire class; or, which will give greater variety and interest, may be divided among the pupils, for each to bring to the recitation all the information obtainable relating to his topic or topics, with liberty to add to that given by others on different subjects, when anything new can be presented. Another day the topics can be assigned to different individuals, and the changes continued till each pupil has thoroughly investigated every topic.

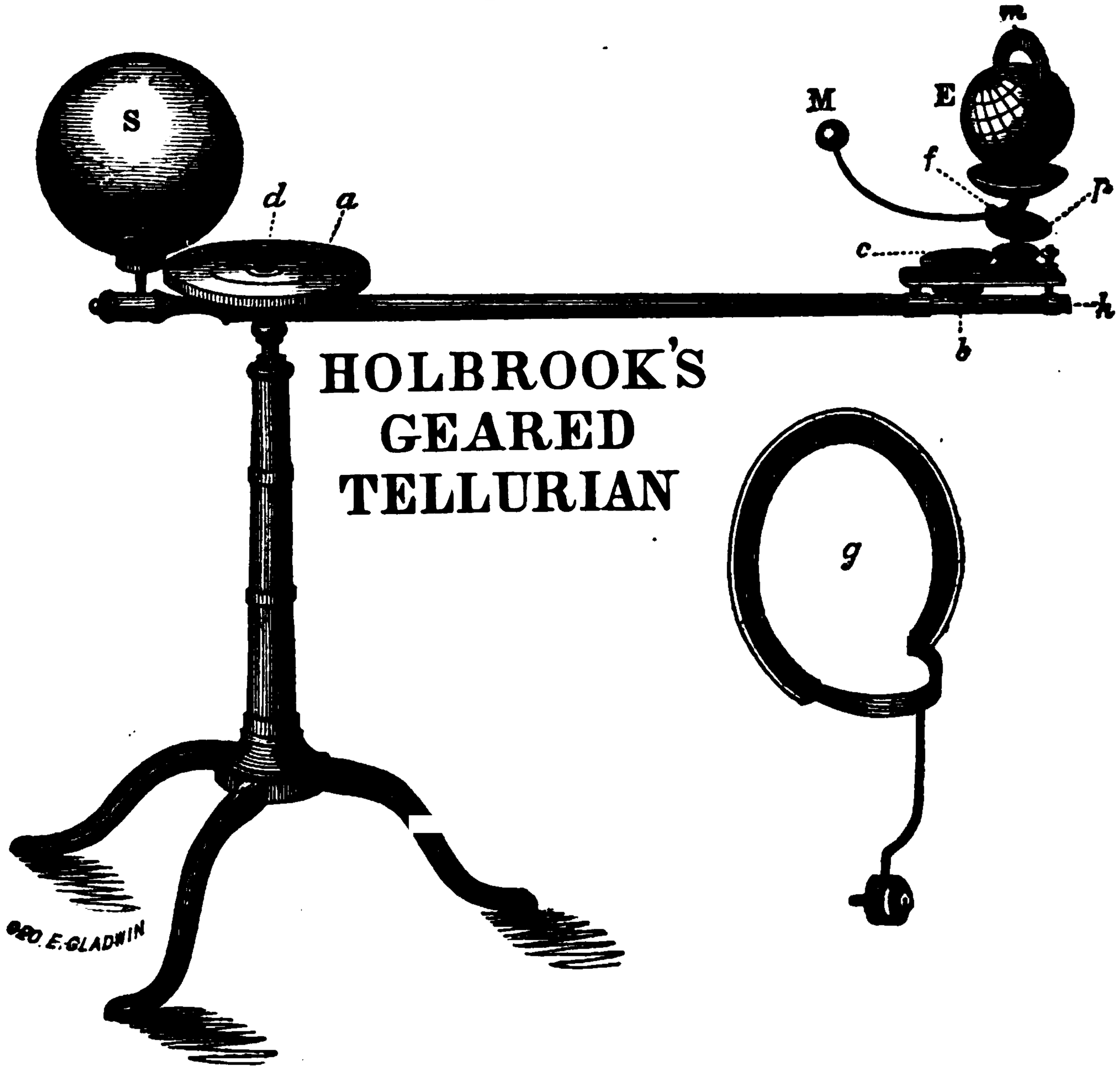
In recitation, all the pupils who are prepared to recite on the particular topic assigned them may signify it by raising the hand. Then one may be required to bound the country, pointing out the adjacent countries on the outline map as he names them; another may give the statistics of the division under consideration; a third describe its surface and soil; a fourth its climate and productions; a fifth speak of customs, religion, and education; a sixth mention capitals and important towns; a seventh the curiosities, natural or artificial. These subdivisions may be as minute as desired, though experience will probably show that several topics can be prepared by each pupil for a single lesson.

To aid them in preparation, books of travels, histories, gazetteers, and other books of reference should be supplied for general use in the school.

If the lesson is prepared in writing, and on paper, it will afford an excellent exercise in grammatical construction, composition, and penmanship, and by preserving the various lessons each pupil will possess a *geography* made by himself.

XI. THE TELLURIAN.

FIG. 15.



In explaining the various phenomena arising from the revolutions of the earth, and its relation to other heavenly bodies, which will naturally suggest themselves to an inquiring pupil, and to which the teacher should never fail to call attention, there will be needed more than the globe.

THE TELLURIAN, OR SEASON MACHINE

Has been prepared expressly for this purpose, and, by the universal testimony of teachers who have used it, has proved admirably adapted to this object. In some of our Colleges, and Normal and High Schools, it supplies an important place, furnishing illustrations better and clearer than can be shown by any other instrument made.

It is designed to illustrate all the phenomena resulting from the relations of the Sun, Moon, and Earth to each other. The most important of these phenomena are the succession of day and night, the change of seasons, the change of the sun's declination, the different lengths of day and night, the rising of the sun north of east in summer, the changes of the moon, solar and lunar eclipses, spring and neap tides, the later daily recurrence of the tides, the length of days on the moon, the appearance of the earth to observers on the moon, the harvest moon, the difference of a synodical and sidereal revolution of the moon, the precession of the equinoxes, and the difference of a solar and sidereal year. All these phenomena may be explained by the use of the Tellurian, with a clearness and simplicity that bring them within the comprehension of a child. The improvements just completed, (July, 1857,) render this instrument the most perfect article now made for the illustrations above named. In place of three cords, (which slight changes of moisture would often render useless,) the gearing requires only one cord, which joins with hooks, and passes around the pulleys, *a* and *b*. When this cord is loose, it may be *unhooked* and *twisted* to any required tension. Before passing to an explanation of its uses in the most important illustrations, the construction of the instrument and its adjustment for use will be described.

CONSTRUCTION OF TELLURIAN.

The Tellurian, Fig. 15, consists of a stand, supporting a revolving arm, and large fixed pulley; gearing and pulley at the end of the arm; the moon's orbit plane;

and three balls, representing the Sun, Earth, and Moon.*

Of these balls, the one representing the Earth is three inches in diameter; the small ball, for the Moon, is seven-eighths of an inch in diameter, giving nearly the true proportionate size. The large ball, for the Sun, is five inches, but the true proportionate size would be nearly twenty-eight *feet*. The proportionate distance of the moon from the earth would be seven and a half feet; while the earth should be placed at the distance of two thousand nine hundred and sixty-nine feet from the Sun. It is perceived that an instrument giving the true proportionate sizes and distances could not well be constructed; and, were it constructed, would require either a telescope or microscope to examine it. Notwithstanding the proportions are not preserved in the Tellurian, the causes of the phenomena appear even more clearly than if they were.

ADJUSTMENT OF TELLURIAN.

In setting up the instrument, screw the upright standard into the base; place the arm on the pivot in the top of the standard, and above it place the large pulley on which are the signs of the zodiac; screw or press this pulley on tightly, and fasten it by means of a brass cap and nut, for the purpose. Place the Sun on the wire at the short end of the arm, and the Earth on the inclined wire at the other end.

Turn the arm till it is directly under the dividing line between Aries and Pisces, in the circle of Signs of the

---

* The words Sun, Earth, and Moon, beginning with capitals, refer to those bodies in the heavens.

Zodiac, which is on the large pulley; this will place the *sun* in the Autumnal equinox.

Now, with the thumb and finger, turn the small pulley, *b*, until the axis of the earth points toward the north; put on the cord (twisted till it is sufficiently tight,) and screw the moon in its place at *f*, and the instrument is ready for use.

If the pulley, *b*, turns, but fails to carry the gearing, hold the gear-wheel, *c*, and turn the pulley, *b*, *backward* till the wheel, *c*, is screwed on firmly. The nut, *d*, should be firmly screwed down in setting up the instrument, to keep the pulley, *a*, from turning.

For showing the change of seasons, length of day and night, &c., remove the moon and wire, (by unscrewing at *f*,) and fasten the day and night circle, *g*, to the end of the arm, *h*, by a screw; the day circle will then surround the earth as at m. The circle and moon can not be used together.

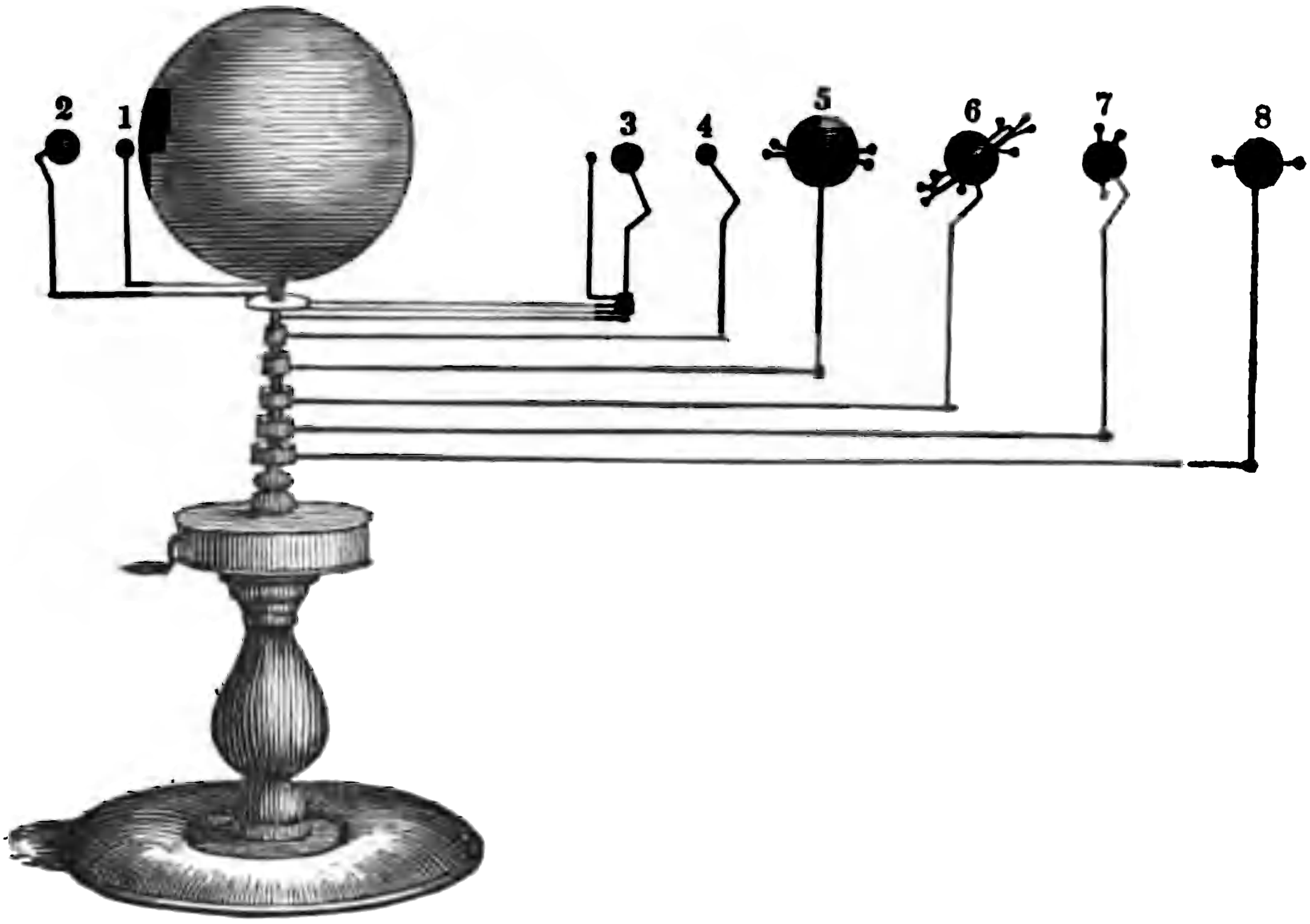
NOTE. The day circle does *not* accompany the six dollar Tellurian; a higher priced one is recommended.

It will be observed that the sun and earth revolve around a common center of gravity; the sun revolves on its axis by coming in contact with the large pulley, and the earth also performs its daily revolutions; the moon revolves around the earth thirteen times while the earth goes aroumd the sun once; and the parallelism of the earth's axis is maintained, the axis always pointing toward the north. The motion of all the balls should be from west to east, in the southern part of their orbits, or, like the hands of a watch moved backward.

(For illustrations with the Tellurian, see Part II. and the Index.)

XII. THE ORRERY, OR PLANETARIUM.

FIG. 16.



The Orrery represents the proportional size and relative position of the planets composing the Solar System, except the asteroids, and shows their annual revolutions. A correct idea of the Solar System is seldom received, except by such aid. With it, we see the planets and their moons circling round their common centre, each in its separate orbit, and system is developed from the seeming chaos of the stars.

ADJUSTMENT OF THE ORRERY.

From the figure, the arrangement of the planets will be easily seen. In setting up the Orrery, the arms which support the planets should be arranged in a line, for

convenience, and pressed on tightly. The planets and Sun being mounted, the revolutions will be shown by turning the crank. By turning the opposite way, the planets will be brought again in a line, in which position the instrument occupies but little space.

CAUTION. The arms should *never be moved except by turning the crank*, as otherwise the machinery is liable to be broken. In removing the arms, loosen them by grasping with the thumb and finger near the socket, and moving the arm *up and down,—never sideways.*

Names of Planets in the order of their distance from the Sun.

1. Mercury, having no moon.
2. Venus, " " "
3. The Earth, " one "
4. Mars, " no "
5. Jupiter, " four moons,
6. Saturn, " eight "
7. Uranus, (or Herschel,)" four (or six) moons.
8. Neptune, (or Leverrier,) having two "

In packing, the four large planets are removed from the wires. Modes of using the Orrery will be given, with the illustrations, in Part II.; also see the Index.

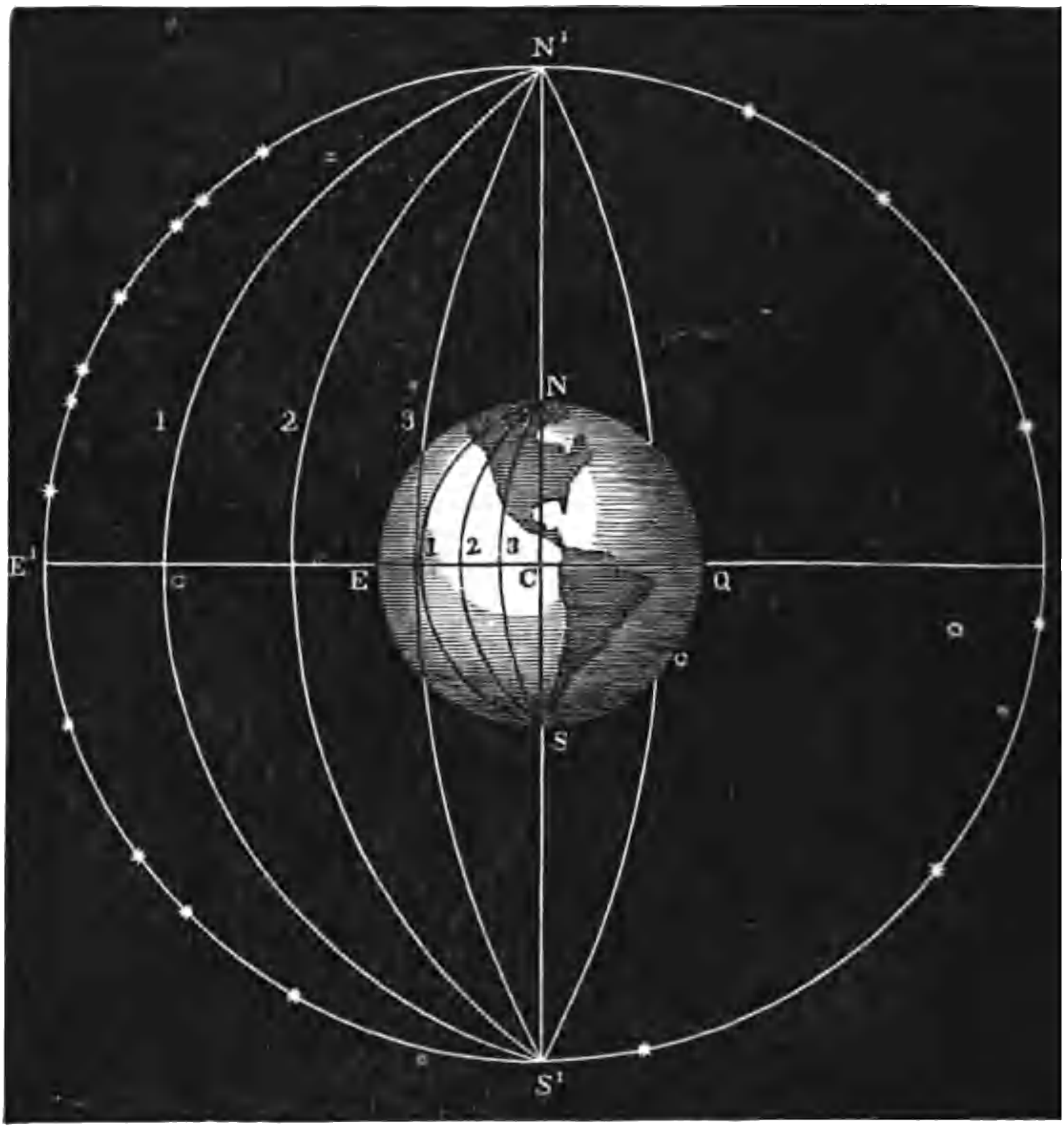
XIII. CELESTIAL SPHERE.

"*The Celestial Sphere is the concave sphere of the heavens*, in which the stars appear to be set.

The *poles* of the earth are the extremities of that imaginary line upon which it revolves; the latter is called the *axis.* If any plane passes through the poles and the axis in any direction, its intersection with the surface of the earth is a circle, and is called a *terrestrial meridian.*

Thus, in Fig. 17, which represents the earth and the celestial

FIG. 17.



sphere, the line N S is the axis of the earth, N, the north pole, S, the south pole, and N E S, N 1 S, N 2 S, N 3 S, are terrestrial meridians.

The axis of the earth, extended in imagination each way, until it meets the starry sky, becomes the axis of the *heavens*, or *celestial sphere*, around which all the stars appear to revolve. The extremities of this axis are the *poles of the heavens*. Thus, in the figure, where the outer starred circle represents a section of the celestial sphere, the line $N^1 S^1$ is the axis of the celestial sphere, and N^1 and S^1 its north and south poles. The axis of

the earth is that part of the axis of the heavens which is intercepted between two opposite points on the earth's surface, and these two intercepting points are the poles of the earth.

If any plane passes through the poles and axis of the heavens, in any direction, its intersection with the imaginary surface of the *celestial sphere*, is a *celestial meridian*. A terrestrial and celestial meridian are therefore formed by one and the same plane; the first occuring when the plane is intersected by the surface of the earth, the second when it is cut by the concave sphere of the heavens. Thus, $N^1 E^1 S^1$, $N^1 1 S^1$, $N^1 2 S^1$, and $N^1 3 S^1$, are celestial meridians; and N E S, N 1 S, N 2 S, and N 3 S, their corresponding terrestrial meridians. * *

When the Sun, in his apparent diurnal revolution, comes to the meridian of any place, it is there noon, or midday; the Latin word for midday being *meridies*."—*Brocklesby's Astronomy*.

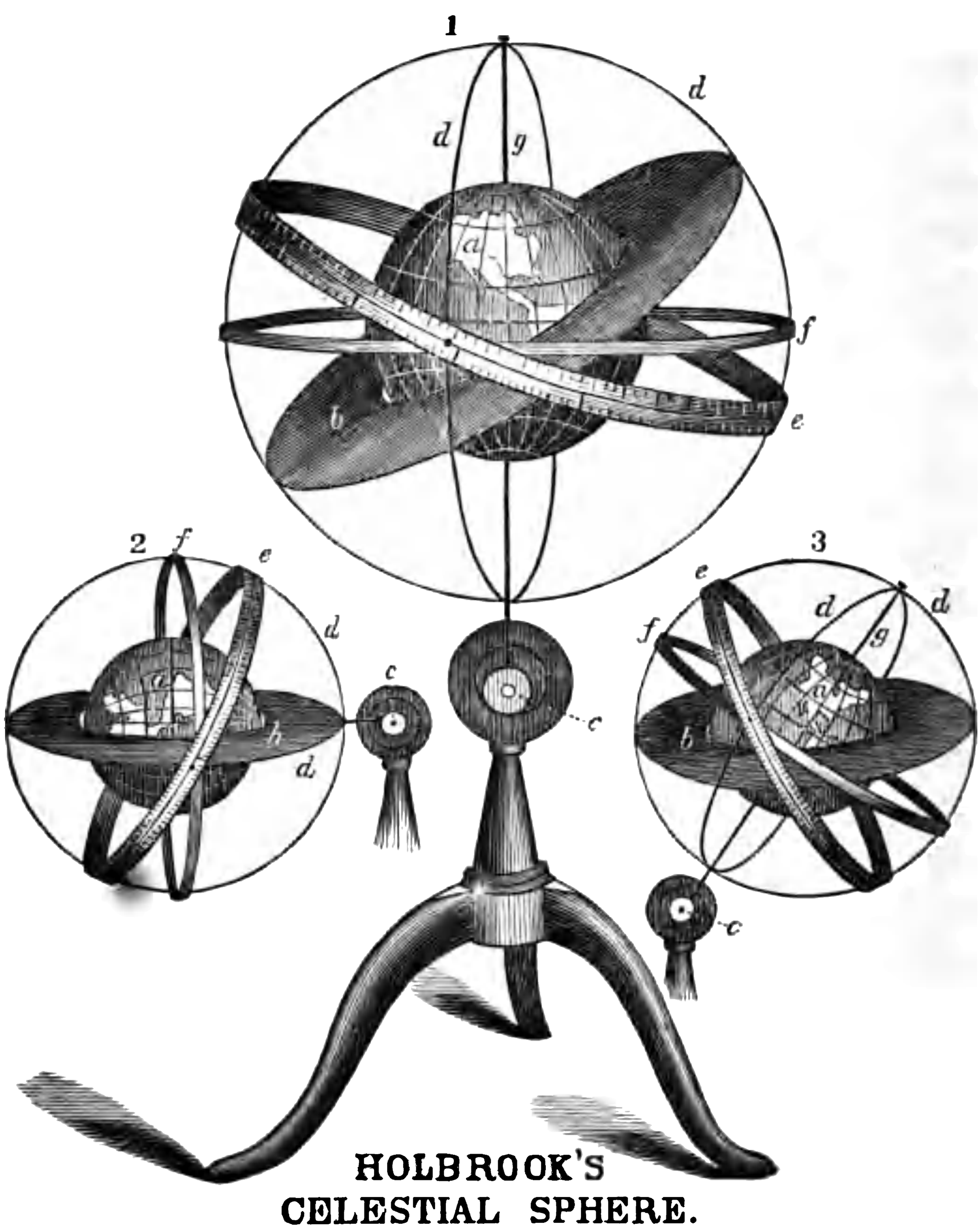
The outer starred line and the celestial meridians, represent the limit of vision in space, and as the eye sees equally far in all directions, this limit must be circular, which will account for the concave appearance of the heavens.

To a person on the equator, that part of the heavens would be visible which is represented by the outer line, $S^1 E^1 N^1$, Fig. 17, and his horizon is represented by the line $S^1 N^1$. One at the North pole would see the part of the heavens represented by $E^1 N^1 Q^1$, while $E^1 Q^1$ would represent his horizon, and the North Star would be directly over head.

An instrument which would illustrate the appearance of the heavens from different points on the earth's surface, and would explain the phenomena visible in different countries, and resulting from changes of position in the observer, will be a valuable addition to the apparatus of Colleges, Academies, and High Schools. Such an instrument is shown in Fig. 18, representing the celestial sphere, with the earth in the center.

CELESTIAL SPHERE.

FIG. 18.



HOLBROOK'S
CELESTIAL SPHERE.

This instrument represents the Earth, (*a*,) surrounded by the heavens, showing the celestial meridians, (*d d*,) the Equator, (*f*,) and Zodiac, (*e*); also the poles of the

heavens, which are simply the poles of the Earth extended. The zodiac is divided into the twelve signs, and is marked with degrees on the lower edge, and months and days on the upper. The brass plates at c, may be loosened by turning the screw for that purpose; and the axis of the sphere may be inclined in any direction, (see 2 and 3 of the figure.) A movable horizon plane, (*b*,) is attached, by which the real horizon of any place on the globe may be shown; also the comparative length of day and night on any part of the earth, and at any season; the time of the sun's rising and setting, together with the sun's place in the Ecliptic,* on any day in the year.

A brass band passing over the globe, supports the horizon plane. The middle of this band is marked by a semi circular notch. Here the person is supposed to be placed, and this notch is moved to different portions of the globe, to represent the changes of position by an observer.

In Fig. 18, (1,) shows the sphere erect; (2,) represents it inclined 90 degrees. This is the position it should occupy to illustrate the appearance to a person at the equator. His horizon would pass through the poles, and the celestial equator would be directly over his head. The position to represent a person at latitude 50°, is shown by (3,) in the figure. In all cases, the sphere should be so inclined that the observer's place will be on the top of the earth, and the movable horizon be parallel to our sensible horizon; for in explanations, we ought always to represent a person as standing on the *top* of the earth, as *seems* to be the case. The *reason* for such appearance can be subsequently explained, but in all cases the illustration

* The line in the middle of the Zodiac, represents the Ecliptic.

and the evidence of the senses should correspond, as far as possible.

By attaching the concave sections* representing the starry heavens, may be shown what stars are above the horizon at any place, and at any hour of any day.

ADJUSTMENT OF CELESTIAL SPHERE.

The adjustment is sufficiently shown in the figure, only let care be taken to place that part of the Ecliptic containing Gemini above, (i. e. North of,) the Equator. (*For modes of using the Celestial Sphere, see Part II, and Index.*)

XIV. THE MAGNET, AND OTHER INSTRUMENTS.

The Magnet needs no description, and its uses are familiar to all. It will be found of essential service in many illustrations, some of which will be mentioned. (See "Magnet," in the Index.) It has recently been added to the Common School Set, because of the varied and constant amusement and instruction it always affords.

Every teacher will find a Mariners' Compass, or magnetic needle, a Syphon, a Kaleidoscope, and a Microscope, which cost but a trifle, of great value, in exciting interest in school and studies; in opening new fields of thought to pupils; and in imparting such collateral information, in connection with the various school duties and exercises, as will expand and strengthen the mind, and create an eager desire for higher attainments. Such is an important part of a teacher's duty, and the extent to which it is performed, marks his ability and excellence.

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* These are not now, (June, 1857,) completed.

NEWELL'S PATENT SPELLING BOX.

THE true way to teach accurate spelling is not by repeating the letters or oral spelling, nor by the phonic, or sound method, but by securing careful attention to the *form* of the letters and words. The eye, and not the ear, is the judge of correct orthography.

The above Spelling Box both teaches, and tests oral teaching, by requiring pupils to spell by sight, and it secures interested attention by calling the hands and mind into active exercise. It may be used as a *silent speller*, the teacher naming the word and each pupil making it in his own box, where the teacher can see each one's work. Its proper place is in the family and the Primary School. Pupils may make entire sentences, using punctuation marks, figures, and letters, as a printer does.

The box contains 250 wooden type, or small blocks, the four sides of each having different letters, figures and marks, thus affording the variety of one thousand letters, with a proper proportion of Capitals and small letters. The blocks are arranged in compartments, as shown in the cut. In the cover are grooves to contain these wooden type, and here the child may give form to his own composition and actually make the words he sees in his primer. For younger pupils such work will be far more attractive, and more useful than poor attempts at printing on a slate with a pencil. Printing and writing with a pencil should properly follow the use of this box, and will be facilitated by it.

Address { *F. C.* BROWNELL, 25 Howard St., N. Y.
GEORGE SHERWOOD, 118 Lake St., Chicago.

PART II. ILLUSTRATIVE.

XV. QUESTIONS ON THE GLOBE, FOR PRIMARY SCHOLARS.

(Some suggestive questions will accompany the illustrations with the globe.)

SHAPE OF THE EARTH.

Question 1. If you place a plate on the top of a small post, and put an ant on it, what will he find when he crawls to the edge? Would he fall off?

2. What would you see if you went to the edge of the earth? i. e. where the sky and earth meet. Would *you* fall off?

3. Has the earth any edge? Is it round like a plate?

4. What is the shape of the earth?

(The object thus far has been to awaken thought in the child's mind. The next thing is to satisfy the curiosity excited.) To say the earth is round, like a ball, and show the globe, will give a correct idea of its shape. But the feeling in the child's mind is, "Why does it *look* flat, then? To answer this, use,

Illustration 1. Cut a circular paper, (card paper is best,) three inches in diameter, with a half inch hole in the center. Place this on the globe. The hole will show that part of the earth visible to the eye, which, being so small, will appear flat. The person is supposed to be in the center, and, as he moves the horizon moves with him; consequently, the *edge* would never be reached, and the earth, though really round, would always *appear* flat.

When the card is moved to the under side of the globe, ask (unless the children do):

5. Why do not people fall off?

Illust. 2. Take a magnet, and, holding the ends up, place a small tack upon it, point downwards. It will

stand erect. What makes it? But, without waiting for an answer, invert the magnet. The tack will remain as before. Ask why it does not fall off. Show that, if removed a little distance, it will *fall up*, i. e., jump back again, as we should if removed from the earth. Call the earth a great magnet, and show that it draws, (attracts,) all things to it, as the magnet does the tack.

6. (The pupils will be likely to ask this.) How do people *know* the earth is round? Perhaps the only answer to this which children in primary schools can comprehend is that people have sailed round it.

Illust. 3. With the globe, start from the southern extremity and go directly East or West till you reach the point from which you started.

Or, leaving the United States, sail East, then South, then East again, and so on, as a ship might go, till it returns, having been around the globe. *Do not sail over the land*, for even *little* children cannot be thus blinded.

7. How do sailors know which way they are going when out of sight of land?

Illust. 4. Let the class face the North, and give them the four cardinal points, viz.: in front, North; at right hand, East; left hand, West; back, South. "If you were blindfolded and led into a round room, and placed with your *faces to the North*, could you tell which way is East, South, &c.?" "If sailors on the ocean knew which way was North could they not find the direction they were sailing?" "They *have* something that will always point North." Now show the Mariners' Compass. Move the needle into various positions, letting the class see it return to its true position. Carry the compass to different parts of the room, showing that it always points *North.*

In connection with this illustration, show them on the globe the Mediterranean Sea, and what parts of the earth adjoining it were inhabited in ancient times. Tell them how little was then known of other parts of the world; that the Earth was believed to be flat, as it looks; how much the Compass helped the sailors after it was invented; tell the story of Columbus, showing his birthplace, the place whence he sailed, course he took, and the land he discovered. Relate the incidents of his voyage and life; speak of those who first sailed round the earth, &c., &c.

Will the children *forget* the illustrations, or the impressions received from them? Will their first lesson upon the Globe be wearisome?

XVI. SIZE OF THE EARTH.

(Mention some well-known place, half a mile distant, and ask how far to it; then a place a mile distant, and so on to as great distances as the pupils have actually traveled. Then ask):

1. How long would it take to walk a mile, i. e., to the place mentioned at that distance,—two miles, five miles, &c. How long to walk round the earth, or 25,000 miles?

(Mention that if a man walked four miles an hour and ten hours a day, stopping Sundays, he would be two years in walking round the earth.)

2. What do we call the distance round the earth?

The circumference, (or the measure around it.)

3. What is the distance through the earth called?

The diameter, (or measure through it.)

(Illustrate by Hemisphere Globe.) Can there be more than one diameter or circumference?

4. How far is it through the earth?

Eight thousand miles.

(Mention time necessary for walking that distance.)

5. Has any one walked round or through the earth?

(Let them give reasons why it could not be done. Their

imaginative and reasoning faculties will find abundant and pleasurable exercise; and the freedom and happiness of the fireside will replace restraint and irksomeness too frequently felt in the school-room.)

XVII. LINES AND DIVISIONS OF THE EARTH.

1. What is a line running through the earth from North to South called?

The Axis of the Earth.

2. Why?

Because the earth revolves around that line as a wheel turns round an axle.

(Illustrate by the Globe, pointing out the axis and turning the Globe on it.)

3. What are the ends of the axis called?

The Poles of the Earth.

How many? Could we see them if we went there?

(The teacher will here speak of *imaginary* lines. To illustrate, make two dots on the blackboard; draw a line from one to the other; then, calling attention to it for a moment, place a paper before it. Ask if they can think how it looks. Erase it, still hiding the board from the class. Again ask if they know how it looks. Remove the paper, and they will see no mark. The line seen by their minds while the paper was before the board was *imaginary*.)

Is the iron on which the globe turns imaginary?

4. Is the axis a diameter or a circumference?

5. What is the name of the line passing round the globe, half way from the poles? (Show the various lines on the globe.)

The Equator.

Is there such a line on the Earth?

6. Is the equator a circumference or a diameter?

7. The lines passing round the earth in the same direction as the equator are just as far from it in one place as another, and, for that reason are called parallels of Latitude. Can you tell what they show?

They show the distance from the equator.

Repeat their names.

(It is not supposed that primary scholars can comprehend the design of the parallels or meridians, or their uses. Hence, only the names are given here.)

8. You see the lines running up and down on the globe. These are rings going round the globe, and each one passes through both the poles. What are their names?

Meridians of Longitude.

Are there such lines around the earth?

9. What shall we call the dotted parallels between the second and third parallels of latitude north of the equator, and the second and third south of it?

Tropics. The one north of the equator is the tropic of Cancer; the one south, the tropic of Capricorn.

10. There are also some dotted lines near the poles, and surrounding them. What are these?

Polar Circles.

(Every circle is divided into 360 equal parts, which we call degrees. In small circles the degrees are short, and in large circles they are long. The degrees of the circumference of the earth are sixty-nine and a half miles long.)

11. How far from the equator to the Tropic of Cancer?

Twenty-three and one half degrees, or 1633½ miles. The Tropic of Capricorn is the same distance south from the equator.

The Polar Circles are the same distance from the poles.

12. What is a Zone?

A belt or girdle.

(Illustrate by a strip of paper placed round the earth.)

13. Between the two tropics is a belt. Can you give its name?

It is the Torrid belt, or Torrid Zone.

Torrid means hot, and this is a hot zone.

14. There is a belt or cap around the North Pole, reaching to the Polar Circle, and one around the South Pole, also. What shall we call these?

Frigid belts or zones. The one at the North Pole is

the North Frigid, the other the South Frigid Zone. Frigid means frozen; and, in these zones, it is always very cold, so that only snow and ice are seen all the year.

15. Between the Torrid and the North Frigid Zones is another belt, which is not so warm as the torrid, nor so cold as the frigid. What shall we call this one?

The Temperate Zone.

16. There is another zone like this between the Torrid and South Frigid Zone. This is a temperate zone, also. How shall we know them apart?

The one north of the equator is the North Temperate Zone, the other the South Temperate.

17. How many zones in all, and what are they called?

Five. Torrid, North and South Frigid, and North and South Temperate Zones.

18. If a round ball or sphere be cut through the middle, it will form two equal parts or halves. What are these called?

Hemispheres, or half spheres.

The foregoing is here inserted in a concise form to be memorized.

LINES AND DIVISIONS OF THE EARTH.

1. What is a diameter of the Earth?

Any straight line extending through the center of the earth from surface to surface.

2. What is a circumference?

Greatest distance around the earth.

3. What is an axis?

That diameter about which the earth revolves.

4. What are Poles?

The extremities of the axis.

5. What are the Great Circles?

Any circle which divides the earth's surface into two equal parts.

6. What is a small circle?

Any circle which divides the earth's surface into two unequal parts.

7. What is the Equator?

The *great circle*, at equal distances from the poles.

8. What are the Tropics?

Two *small circles*, $23\frac{1}{2}$ degrees from the equator.

9. What are the Polar Circles?

Two *small circles*, $23\frac{1}{2}$ degrees from the poles.

10. What are Meridians?

Great circles passing through the poles and the equator

11. What are Parallels of Latitude?

Small circles parallel to the equator, either north or south of it.

12. What is a zone?

A belt or girdle, surrounding the earth.

13. What is the Torrid Zone?

That portion of the earth's surface between the tropics.

14. What are the Temperate Zones?

The two belts between the tropics and polar circles.

15. What are the Frigid Zones?

Those portions of the earth's surface inclosed by the two polar circles.

16. What are Hemispheres?

Any two equal divisions of the earth; as, northern and southern, eastern and western.

REMARK 1. All mathematical lines and divisions are imaginary.

2. By the use of the globe, on which the imaginary circles are drawn, the other lines and divisions can be clearly pointed out and explained.*

* The above is repeated in Part III., Lesson I.

THE LATITUDE of a place is its distance from the equator, and is usually reckoned in degrees. If the place is north of the equator it is in north latitude; if south, it is in south latitude.

THE LONGITUDE of a place is its distance from the *first meridian*, and is reckoned in degrees.

THE FIRST MERIDIAN is the one passing through Greenwich. Any place east of this meridian is in east longitude, and any place west of it is in west longitude.

THE ECLIPTIC is a great circle representing the apparent path of the sun during the year. It is inclined to the equator 23½ degrees, and extends from one tropic to the other. The two places where the ecliptic crosses the equator are called the *equinoctial* points.

SIGNS. The ecliptic is divided into 12 equal parts called signs, each containing 30 degrees. Six of these are north of the equator and six south of it.

THE VERNAL EQUINOX is at the first point of the sign Aries, and the sun is then crossing the equator to enter the northern signs, causing our spring and summer.

THE AUTUMNAL EQUINOX is at the first point of the sign Libra, where the sun again crosses the equator to enter the southern signs, bringing to us autumn and winter. When the sun is on the equator (or at the equinoxes) the days and night are equal all over the world, and because equi-nox means equal night, these points were named equi-noxes.

THE SOLSTICES or SOLSTITIAL POINTS are the points where the sun touches the tropics and turns to go toward the equator. One is north of the equator, and the sun is there in our summer; hence we call it the

Summer Solstice. The other is south of the equator, and when the sun is there we have winter; hence that is called the Winter Solstice.

The ZENITH is the point directly over our heads.

The NADIR is a point in the heavens directly below our feet. Both Zenith and Nadir move when we move.

THE VISIBLE HORIZON is where the earth and sky seem to meet, and is a small circle around the zenith.

The REAL HORIZON is a *great* circle 90 degrees from the zenith, having half the heavens above it and half below. The Horizon moves when we move.

The ALTITUDE of any heavenly body is its distance from the horizon; its ZENITH DISTANCE is its distance from the zenith.

PARALLELS OF ALTITUDE are imaginary circles parallel to the horizon.

VERTICAL CIRCLES are great circles passing through the zenith and nadir, cutting the horizon at right angles. The one passing through the north and south points of the horizon is a meridian.

The PRIME VERTICAL is the vertical circle passing through the east and west points of the horizon.

The AZIMUTH of a star is the distance measured on the horizon between a vertical circle passing through the star and the north or south points of the horizon; the distance of a star from the east or west point is called its AMPLITUDE.

The DECLINATION of a heavenly body is its distance north or south from the celestial equator, or equinoctial, and corresponds to latitude on the earth.

The RIGHT ASCENSION of a heavenly body is its

distance east or west from the first meridian, which passes through the first point of Aries.

The CARDINAL POINTS are east, west, north and south. In the heavens the cardinal points are the zenith and nadir. The cardinal points of the ecliptic are the equinoxes and solstices.

The MAGNETIC NEEDLE always points toward the north, and enables us to determine the cardinal points. When attached to a card on which are the thirty-two points of the compass, it constitutes the MARINER'S COMPASS.

The REAL HORIZON is represented on most of the expensive, or fully mounted globes by a *wooden horizon*, having usually seven concentric circles. The *first* or *inner* circle is for finding amplitude of heavenly bodies; the *second* for finding their azimuth. The *third* contains the thirty-two points of the compass; the *fourth*, the twelve signs of the zodiac, each divided into thirty degrees; the *fifth* shows the days of the months corresponding with the degrees of the ecliptic; the *sixth* shows the difference between the time by a clock and by a sun-dial, or the equation of time; the *seventh* contains the twelve calendar months.

The HOUR CIRCLE around the north pole is divided into twenty-four equal parts which correspond to the hours of the day. It is furnished with an index and is used for finding the length of days and nights, difference of time, &c.

The POSITIONS of the Sphere are these: right, parallel and oblique.

A RIGHT SPHERE is when the horizon is at right angles to the equator, as would be the case to people at the equator.

A PARALLEL SPHERE is when the *visible* horizon is

parallel to the equator, and consequently the real horizon will coincide with the equator. This would be the case to people at the poles, and the poles would coincide with the zenith and nadir.

An OBLIQUE SPHERE is when the horizon is oblique to the equator, as would be the case on all parts of the earth except at the poles and the equator.

The ANALEMMA is a scale drawn from one tropic to the other showing the sun's distance north or south of the equator on any day in the year. It contains the months and days, and the signs of the zodiac.

PROBLEMS ON THE TERRESTRIAL GLOBE.

PROBLEM I. *To find the latitude of any place.*

WITH PEDESTAL GLOBE. (*Mark a strip of paper with* 90 *degrees of the length given on the equator. This will make a paper quadrant which may be used in the same way as the brass quadrant.*) With the quadrant measure the distance from the equator to the place, on a direct line to the pole. This distance is the latitude.

WITH MERIDIAN GLOBE. Bring the place to the edge of the metallic meridian. The degree over the place counted *from the equator*, gives the latitude.

If the place is north of the equator it is in north latitude; if south, in south latitude.

EXAMPLES.*

1. What is the latitude of Constantinople? (A. 41° N.)

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* The latitude and longitude in these examples will not be given with astronomical exactness, but with such a degree of accuracy as a pupil can give from the globe.

2. Latitude of Rome, (42° N.); Paris, (49° N.); Cape Horn, (56° S.); Philadelphia, (40° N.); New Orleans, (30° N.); Quito, (00°.)

3. What places have no latitude? A. Those on the equator.

4. What places have the greatest latitude? A. The poles.

PROBLEM II. *To find all places in the same latitude with a given place.*

RULE. Find the latitude of the given place (by Prob. I.) Turn the globe on its axis, and all places passing under the same degree on the meridian or quadrant will be in the same latitude.

EXAMPLES.

1. What places have nearly the same latitude as Philadelphia? A. Pekin, Constantinople, Naples, Madrid, Columbus, Salt Lake City.

2. What places have nearly the same latitude as New Orleans? as London?

PROBLEM III. *To find the difference of latitude between two places.*

RULE. Find the latitude of each place (by Prob. I.,) then if both places are in north or south latitude, subtract their latitudes; but if one place is in north and the other in south latitude, add the two latitudes.

EXAMPLES.

1. What is the difference of latitude between Philadelphia and Calcutta? A. 16½°.

2. Difference of latitude between Philadelphia and Cape of Good Hope? A. 74°.

3. What two places have the greatest difference of latitude? A. The poles.

PROBLEM IV. *To find the longitude of any place.*

WITH PEDESTAL GLOBE. With the quadrant, or a slip of paper, find where a meridian line from the pole through the place will cut the equator. The number of the degrees on the equator from the *first meridian* to this point will be the longitude of the place.

WITH THE MERIDIAN GLOBE. Bring the place to the edge of the metallic meridian; the degree on the equator cut by this meridian is the longitude of the place.

Any place on the right hand of the first meridian is in east longitude; on the left hand, in west longitude.

All places on the same meridian are in the same longitude, and all have noon at the same time.

EXAMPLES.

1. What is the longitude of Paris? A. 2° E.

2. Longitude of Philadelphia, (75° W.); New Orleans, (90° W.); San Francisco, (122° W.); St. Petersburg, (30° E.); Calcutta, (91° E.)

PROBLEM V. *To find the difference of longitude between two places.*

RULE. Find the longitude of each place (by Prob. IV.); then if both are in east or both in west longitude, subtract their longitudes for the difference. If one is in east and the other in west longitude, add the two longitudes for the difference in degrees between the two places.

EXAMPLES.

1. What is the difference of longitude between St. Helena and the Bermudas? A. 60°.

2. Between the Straits of Gibraltar and Constantinople, (35°).

3. Between Boston and Rome, (84°.)

PROBLEM VI. *To find the distance between two places.*

RULE. With the quadrant measure the distance in degrees. Multiply the number of degrees by 60 for the geographic miles, or by 69½ for the English miles.

The degrees may also be found by measuring between the two places with a pair of dividers or a thread, and applying this measure to the equator.

EXAMPLES.*

1. What is the distance between Washington and San Francisco? A. 36° or 2,490 English miles.

2. Distance from New York to London? (50° or 3,458 English miles.)

3. Distance across South America from Cape Blanco to Cape St. Roque? (46° or 3,181⅔ English miles.)

4. Distance from Paris to St. Helena? (66° or 4,565 English miles.)

PROBLEM VII. *To find any place whose latitude and longitude are given.*

WITH PEDESTAL GLOBE. Lay the quadrant on the globe from the pole to the equator so that its edge shall form a meridian at the longitude given; then at the given latitude on the quadrant, you will find the place required.

WITH MERIDIAN GLOBE. Bring the given longitude as marked on the equator, to the meridian; under

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* In the examples under this problem, the distance is given in degrees of the length of a degree at the equator, as such only would be found by the rule.

the given latitude on the meridian, will be the place sought.

EXAMPLES.

1. What island is in 50° north latitude and 125° west longitude? A. Vancouver's Island.

2. Some shipwrecked sailors who are out of sight of land, find by the sun that they are in 40° north latitude and 35° west longitude. What is their place on the globe, and what land is nearest them? In what direction must they sail to reach land the soonest? A. They are nearest the Azores Islands, and must sail a little south of east.

3. Another company are at 30° south latitude and 110° west longitude; what land is nearest them; in what direction, and how far must they sail to reach it? (*Find the distance by Prob. VI.*)

PROBLEM VIII. *The hour of the day being given at any place, to find what hour it is at any other place.*

RULE. Find the difference of longitude between the two places (by Prob. V.) and reckon one hour's difference in time for every 15 degrees in longitude, or 4 minutes for every degree. If the place where the time is required is *east* of the other place, *add* this difference of time to the given time; but if it is *west*, subtract the difference.*

WITH MERIDIAN GLOBE. Bring the place whose time is given, to the edge of the metallic meridian; set the index of the hour circle to 12; revolve the

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* *The circumference of the earth is divided into* 360 *degrees, and it revolves once in* 24 *hours, hence in one hour it will revolve* 1-24 *of* 360 *degrees, which is* 15 *degrees, and consequently every* 15 *degrees east or west will make a difference of an hour in time. When it is noon with us, to all places east of us it is afternoon, and to all west of us it is before noon, or the time later as we go east, and earlier as we go west.*

globe till the other place comes to the edge of the meridian, and the hours passed over by the index will be the difference in time between the places.

All places on the same meridian have the same time.

EXAMPLES.

1. What hour is it at London when it is noon at Philadelphia. A. It is 5 o'clock, P. M.

(*London is* 75° *east from Philadelphia, which makes* 5 *hours later time.*)

2. What is the hour at St. Petersburg, when noon at Philadelphia? (7 P. M.); what at San Francisco? (8.52 A. M.); at Calcutta? (11 P. M.)

3. What hour in Chicago when 9 A. M. at New York?

PROBLEM IX. *To find the difference of longitude between two places when the difference of time is known.*

RULE. Reckon 15 degrees of longitude for every hour of time, and 1 degree for every four minutes of time. If the time is later, the longitude is east; if earlier, it is west.

EXAMPLES.

1. When it is noon in London it is 2 o'clock P. M. at a certain place in the 47° north latitude. What is the longitude of the place, and what place is it?

A. The place is in 30° east longitude; it is named Odessa and is on the shore of the Black Sea.

2. A ship sails from London carrying a watch which keeps London time. After a long voyage the captain finds by the sun that he is in 20° south latitude, and when it is noon by the sun-dial it is 8 o'clock A. M. by his London time; what is his longitude, in what ocean is he, and what is his nearest land?

A. He is in 60° east longitude, in the Indian Ocean, and nearest Mauritius, the Isle of France.

It is in this way sailors find where they are on the ocean. Ask your teacher what a sun-dial is, and how they can find when it is noon by it.

PROBLEM X. *To find the length of a degree of longitude at any given latitude.*

RULE. Measure the distance between any two meridians at the given parallel, and see how many degrees it occupies on the equator or quadrant. Multiply this number of equatorial degrees by 69$\frac{1}{6}$ and you have the distance in miles between the two meridians at the given latitude; and this distance divided by the number of degrees between the two meridians (15° on most globes) will give the length of one degree.

EXAMPLES.

1. What is the length of a degree of longitude in the latitude of 60°?

The distance between two meridians (15° apart) at 60° of latitude makes 7$\frac{1}{2}$ degrees of the equator, which multiplied by 69$\frac{1}{6}$ miles in one degree = 518 miles, or the distance between the two meridians at 60° of latitude. But these meridians are 15° apart; hence the length of one degree will be $\frac{1}{15}$ of 518 miles = 34.5 miles.

2. What is the length of a degree of longitude at latitude 40°? (52.9 miles.)

PROBLEM XI. *To find how fast per hour, the people of any place are carried from west to east by the revolution of the earth on its axis.*

RULE. Find the number of miles in 15° of longitude at the latitude of the given place (by Prob. X.;)

which will be the distance the earth moves in one hour at that place.

EXAMPLES.

1. How far does the earth move from west to east in an hour at latitude 30°?

The distance between two meridians at latitude 30° is equal to 13 degrees on the equator, which multiplied by $69\frac{1}{6}$ (miles in a degree) gives 899 miles as the distance the earth moves every hour.

2. How fast does the earth move per hour at the equator? ($1,041\frac{2}{3}$ miles.) How fast at latitude 60°? (518 miles.)

3. How fast at latitude 80°? (180 miles.) How fast at the poles?

4. How fast do we move?

PROBLEM XII. *To find the Antipodes* of any place.*

RULE. Find the latitude and longitude of the given place; then on the meridian of longitude directly opposite (*i. e.* 180° distant) find a place at the same degree of south latitude as the given place is of north latitude, (or in north latitude if the given place is in south latitude,) which will be the antipodes of the given place.

EXAMPLES.

1. Find the antipodes of Quito. A. The island of Sumatra.

2. Antipodes of Pekin? A. Northern part of Patagonia.

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* The Antipodes (or *opposite feet*) of any place is that part of the earth which is *directly opposite*, and the feet of two persons in the two places will be opposite each other. People at the antipodes have the seasons, days and nights, latitudes and longitudes, opposite.

3. Antipodes of Bermuda Islands? A. South-west part of New Holland.

4. Antipodes of North Pole? A. South Pole.

PROBLEM XIII. *To find the sun's place in the ecliptic for any given day.*

RULE. BY PEDESTAL GLOBE. Find the month and day in the analemma. The sign and degree in the analemma corresponding to it will be the sun's place, which may then be found in the ecliptic drawn around the globe.

BY MERIDIAN GLOBE. Find the month and day in the analemma; bring it to the meridian, and find its distance in degrees from the equator; then revolve the globe till a point in the ecliptic comes under this degree, which point will be the sun's place.

This rule is necessary for globes whose analemma does not contain the signs.*

BY HORIZON GLOBE. Find in the circles on the horizon the month and day, and the corresponding sign and degree, which may then be found in the ecliptic drawn on the globe.

EXAMPLES.

1. What is the sun's place in the ecliptic on the 20th day of May?

A. At the 29th degree of the sign (♉) Taurus.

2. What on the 21st of December. A. At the first point of the sign (♑) Capricornus.

PROBLEM XIV. *To find the sun's declination* (or distance north or south of the equator) *on any given day.*

BY PEDESTAL GLOBE. Find the sun's place in the

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* The new 8 inch globe made by the Holbrook School Apparatus Company, has a *complete* analemma, containing months, days, signs and degrees.

ecliptic (by Prob. XIII.) for that day. The distance of this point from the equator measured in degrees, is the sun's declination.

NOTE. This distance may be measured by the quadrant, either from the place as found in the analemma or from the place in the ecliptic, since both correspond in distance.

BY MERIDIAN GLOBE. Find the sun's place and bring it to the metallic meridian. Above it on the meridian is the degree of declination, either north or south.

EXAMPLES.

1. What is the sun's declination on the 20th of May? A. 20° North.

2. What is the sun's declination on the 21st of December? (23° 30′ S.)

3. What declination has the sun, March 20th? (0.) Why?

PROBLEM XV. *To find all places where the sun is vertical,* (directly over head,) *at noon of a given day.*

BY PEDESTAL GLOBE. Find the sun's declination in degrees (by Prob. XIV.) for the given day; the sun will be vertical at noon at any place in the same latitude* as the sun.

BY MERIDIAN GLOBE. Find the sun's declination for that day in degrees, on the meridian. Revolve the globe. All places passing under this degree on the meridian will have the sun vertical at noon.

EXAMPLES.

1. Where is the sun vertical at noon on the 15th of

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* *Latitude* on the earth means the same as *declination* in the heavens.

April? A. At all places in 10° north latitude. Name the principal places.

2. Where is the sun vertical at noon on the 21st of June? (At the tropic of Cancer.)

3. Where, on the 22d of December? (At the tropic of Capricorn.)

NOTE. The sun will be vertical *two* days in each year, to every place in the torrid zone, because it passes across this zone and back in a year.

PROBLEM XVI. *The day and hour being given at any particular place, to find where the sun is then vertical.*

BY MERIDIAN GLOBE. Find the sun's declination for the given day, (by Prob. XIV.,) which is the latitude of the required place; bring the given place to the metallic meridian; set the index to the hour given; then turn the globe till the index points to XII., noon; then under the meridian, and in the same latitude as the sun's declination, is the place where the sun is vertical.

NOTE. All places then under the metallic meridian will have noon, but at only one will the sun be vertical.

BY PEDESTAL GLOBE. Find the sun's declination for the given day, (by Prob. XIV.,) which is the latitude of the required place; then from the given place, count degrees of longitude* sufficient to make the difference in time between the given time and noon, (counting 4 minutes to a degree,) and you will have the longitude of the place required, and the

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* If the given time is before noon, count east, and if after noon, count west, from the given place.

point where the lines of latitude and longitude would meet, will be the place sought.

EXAMPLES.

1. On the 17th of May at 40 minutes after 1 o'clock, P. M., by the time in Philadelphia, where is the sun vertical? A. At Mexico.

2. At 4 o'clock, P. M., in Madrid, August 25th, where is the sun vertical? At the island of Trinidad.

3. At 5 o'clock, P. M., in Charleston, July 22d, where is the sun vertical? At the largest of the Sandwich Islands.

PROBLEM XVII. *To rectify the globe for a given place.*

NOTE. To *rectify* a globe means to *make it right*, that is, to place it as it would appear to a person in the given place. One's horizon is always 90° from his zenith, and *seems* never to move; hence, rectifying the globe for any place, consists in putting that place 90° from the horizon frame. And as we always seem to stand on the *top* of the earth, the place for which the globe is rectified must be brought to the highest point *above* the horizon. To represent the *reality*, the *horizon* should change with change of place, while the globe remains stationary, but this would be inconvenient and would *seem* unnatural, hence the

RULE.* Raise the corresponding† pole as many degrees above the wooden horizon as will equal the latitude of the place, and bring the given place to the meridian.

WITH PEDESTAL GLOBE. Place the horizon‡ as

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* Most of the following problems need the horizon globe.

† If the place is in north latitude, the north pole must be above the horizon; if in south latitude, the south pole.

‡ A convenient and very useful horizon for a pedestal globe may be easily made by cutting from a piece of stiff card paper, a ring two inches wide, whose inner diameter shall be half an inch more than the diameter of the globe. This ring, suspended around the globe by a band of ribbon

many degrees below the proper pole as will equal the latitude of the given place, and move or hold the globe so that this place shall be at the top of it.

PROBLEM XVIII. *To find the hours of sunrise and sunset and the length of day and night at a given place on a given day.*

RULE. Rectify the globe for the given place (by Prob. XVII.) Find the sun's place in the ecliptic (by Prob. XIII.,) and bring it to the metallic meridian. Set the index of the hours to XII.; turn the globe eastward till the sun's place comes to the edge of the horizon; the *number of hours passed over* by the index will give the hour of sunset; while the hour at which the index points* will be the time of *sunrise.*

Doubling the hour of sunset gives the length of the day; and doubling the hour of sunrise, the length of the night.

EXAMPLES.

1. At what hour does the sun rise and set at Madrid on the 15th of April, and what is the length of the day and night? A. It rises at 5 and sets at 7; the day is 14 hours long and the night 10 hours.

2. What is the hour of sunrise, and sunset, and the length of day and night, at New Orleans on the same day, April 15th. (Sun rises at $5\frac{1}{2}$ and sets at $6\frac{1}{2}$; day is 13 hours long, night 11 hours.)

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passing over the globe and attached to the inner edges of the ring, and of such length that when the band passes over the pole, the ring will coincide with the equator, will form the true horizon of any place covered by the middle point of the band. For convenience, the middle of the band should be marked.

* If the hour circle is *double*, the index will point to the hour of sunrise in one circle, and the hour of sunset in the other.

3. What is the hour of sunrise, and sunset, and the length of day and night, at Cape Farewell on the same day, April 15th? (Sun rises at $4\frac{3}{4}$ and sets at $7\frac{3}{4}$, or $\frac{1}{4}$ before 8. The day is $15\frac{1}{2}$ hours long and the night $9\frac{1}{2}$ hours.)

4. What is the hour of sunrise and sunset, and what the length of day and night, at the North Cape on the same day, April 15th? (Sun rises at $3\frac{3}{4}$ and sets at $8\frac{1}{4}$. The day is $16\frac{1}{2}$ hours long and night $7\frac{1}{2}$ hours.)

5. What is the hour of sunrise and sunset, and what the length of day and night, on the same day, April 15th, at Cape Horn? (Sun rises at 7 and sets at 5. Day is 10 hours long, night 14 hours.)

NOTE. The longest day at any place north of the equator and not in the frigid zone, will be the 21st of June, and the shortest day the 21st of December. The longest day north of the eqautor will be the *shortest* day to places south of the equator.

PROBLEM XIX. *To find how long the sun shines without setting, at any given place in the north frigid zone; also, how long it is invisible.*

RULE. Rectify the globe for the latitude of the given place, (by Prob. XVII.;) turn the globe till the north point of the horizon cuts the ecliptic *between the first point of Aries and Cancer.* At this point the sun begins to shine continually* on the

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* This may be illustrated by sticking a bit of wafer on the globe at this point, to represent the sun; as the globe is revolved, the pupils will see that the wafer or sun is *always* above the horizon on that day. Next day it will be still higher in the ecliptic, and consequently further above the hori-

given place. Find by the analemma or by the wooden horizon, the same degree of the ecliptic and the day of the month corresponding to it, which will be the first day when the sun *does not set.* Then turn the globe till the north point in the horizon cuts the ecliptic *between the first point of Cancer and Libra.*

The day and month corresponding to this degree, shown by the analemma or horizon, will be the day when the sun *begins to set* at the given place; the difference between these days will show how long the sun has been above the horizon. During this time, the sun has been *invisible* to all places on and above the corresponding degree of south latitude; and hence by a similar process with a place in the same degree of south latitude, we may find when the sun ceases to set there; at which time it will cease to be visible at the given place in the north frigid zone.

EXAMPLES.

1. How long will the sun remain above the horizon at the North Cape, in latitude 71½° north? A. The sun ceases to set the 14th day of May, and is above the horizon from that time until July 30th, being 77 days.

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zon, and so on. A good illustration of the appearance of the sun may be found on pages 91 to 93 of the GUIDE TO ILLUSTRATION.

PROBLEM XX. *To find when twilight begins and ends at any place on a given day.*

RULE. Rectify the globe for the latitude of the given place, (by Prob. XVII.;) and screw the quadrant upon the metallic meridian at the latitude of the given place; bring the sun's place in the ecliptic or in the analemma, for the given day, to the meridian, and set the hour index to 12. Now turn the globe westward till the sun's place comes to the horizon, when the index will point to the hour of sunset, or the beginning of evening twilight; turn the globe still farther till the sun's place coincides with 18° below the horizon, as marked on the quadrant, when the hour index will point the end* of evening twilight.

When the sun's place coincides with 18° on the quadrant, below the *eastern* horizon, morning twilight begins.

EXAMPLES.

1. When does morning twilight begin, and evening twilight end, at Philadelphia on the 25th of May? A. Morning twilight begins at $2\frac{3}{4}$, and evening twilight ends at $9\frac{1}{4}$.

2. When, at London, on the 22d of September? Morning twilight begins at 4; evening twilight ends at 8.

PROBLEM XXI. *To find the sun's meridian altitude.*†

RULE. Rectify the globe for the latitude of the given

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* Twilight extends 18 degrees from the sun, beginning 18 degrees before sunrise, and ending when the sun is 18 degrees below the horizon. Morning twilight ends with sunrise, and evening twilight begins with sunset.

† *Meridian altitude* is the distance above the horizon at noon.

place, (by Prob. XVII.,) and bring the sun's place in the ecliptic, (or analemma,)' for the given day, to the meridian. This is where the sun is at noon, and of course the number of degrees on the meridian from this point to the horizon, is the sun's meridian altitude.

EXAMPLES.

1. What is the sun's meridian altitude at Philadelphia, May 29th? A. 71¾.

2. What, at London, June 21st? (62°.)

3. What, at Paris, August 1st? (59°.)

4. What, at London, Dec. 22d? (15°.)

5. What, at the North Pole, March 21st? (0°. The sun is on the horizon, just rising after the long winter night.)

PROBLEM XXII. *Having the sun's meridian altitude at any place on a given day, to find the latitude of that place.*

RULE. Find the sun's place in the ecliptic or analemma, for the given day, and bring it to the meridian; elevate or depress the pole till the sun's place (still on the meridian) is as many degrees above the horizon * as the given meridian altitude; the wooden horizon now corresponds to the horizon of the place, and is 90° from it. Hence, count from the *horizon*, along the meridian 90°, and on the meridian (counting from the *equator*) will be the latitude sought.

NOTE. If the sun was south of the observer when the altitude was taken, the place is in north latitude, but if the sun was north, the place is in south latitude.

EXAMPLES.

1. On the 21st of June the sun's meridian altitude,

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* If the sun was north of the observer when the altitude was taken, reckon from the north point of the horizon; if south, reckon from the south point.

south from a certain place, is 63½°; what is the latitude of the place? A. 40° north latitude.

2. At a certain place, on the 21st March, the sun at noon is 65° from the horizon, and is north from the place, i. e., nearest the north point of the horizon, what is the latitude of the place? (65° south latitude.)

3. Some sailors at noon of Dec. 21st, see the sun in the south, and only 10° above the horizon; in what latitude are they? (56½° north latitude.) By their watch which keeps London time, it is 3 o'clock, P. M., in what longitude are they, (see Prob. IX.) and where on the globe are they (see Prob. VI.)? (They are in longitude 45° west, and are in the Atlantic ocean, 3½° or 243 miles south of Cape Farewell in Greenland.)

PROBLEM XXII. *To place the globe in the* SUNSHINE *so as to show the actual position of the earth in relation to the sun.*

RULE. Set the globe directly north and south by the aid of a compass; rectify the globe for the latitude of the place in which you are, (by Prob. XVIII.)

NOTE. The globe will now correspond to the situation of the earth, and all the lines drawn on the globe will correspond with the same imaginary circles in the heavens. The part of the earth on which the sun then shines will be correctly represented by that part of the globe which is above the horizon, and in the sunshine.

PROBLEM XXIII. *To find where a lunar eclipse will be visible at a given hour.*

RULE. Find (by Prob. XVI.) where the sun is vertical at the given hour; bring this place to the brass

meridian, and rectify the globe for the place by (Prob. XVIII.) To all places above the horizon, it is now day, while all *below* it have night, and to them only, an eclipse of the moon will be visible.

NOTE. To bring the places which have night (and the eclipse visible) above the horizon, that they may be more readily seen, we have simply to turn the globe half round; that is, set the hour index to XII., noon, and turn the globe till XII., night, comes under the index.

PROBLEM XXIV. *To find the hour of the day at any place whose latitude is known, by placing the globe in the sunshine.*

RULE. Place the globe in the sunshine, directly north and south, and parallel with the visible horizon; rectify the globe for the place (by Prob. XVIII.;) bring the first meridian to the metallic meridian; and number the points where the hour circles on the globe cut the wooden horizon for the hours, thus: at the meridian will be XII., noon, the points *west* from this will be XI., X., &c., A. M., and the points *east*, I., II., &c., P. M.; this is the sun dial; now at the pole, which is in the sunshine, stick a long pin and the point where its shadow falls on the wooden horizon (or dial) will show the hour of the day.

XVIII. THE EARTH SPHERICAL.

That the Earth is spherical, appears from the following proofs and illustrations:

Proofs that the Earth is Spherical.

1. Circumnavigation
2. Appearance of ships at sea.
3. Shadow on the Moon.
4. Appearance of the Polar Star.
5. Vertical and horizontal lines.
6. Attraction.
7. Analogy.
8. Actual measurement.

Proof 1. People have traveled around the earth.

Illustration. As a fly, crawling around the globe in any continuous direction, comes back to the starting point, so travelers have passed around the earth in nearly all directions, and returned to their homes.

Proof 2. On the ocean, which must show the exact shape of the earth, the upper part of an approaching object is seen first. When a ship comes in sight, the tops of the masts are first seen, then the sails, and lastly the hull.

Illustration. Insert a pin into the globe, and turn the globe. The outer extremity is first seen, when approaching, and disappears last when receding.

Proof 3. The shadow of the Earth on the Moon is always circular.

Illustration. The globe always casts a circular shadow, whereas no other body, in all positions will do so. Try a cylinder, a cone, oblate and prolate spheroids, and then the globe.

Or, with the Tellurian, held in the sunshine, show that

the moon's shadow on the earth is always round. Then remove the moon, and substitute a circular piece of card paper. This will cast a round shadow, an ellipse, or a line, according to its position. Apply this to the shadow of the earth, which is *always* round.

Proof 4. The North Star rises as we travel north, and declines as we go south, till we reach the equator, when it disappears.

Illustration 1. The globe being on a stand, let the north pole be directed toward any small object, as a nail in the ceiling. If that nail represent the north star, and a short pin a traveler, and the pin be moved from the pole toward the equator and across it, then will it appear that the globe will intercept the line of vision from the traveler to the star soon after crossing the equator.

Illust. 2. With the HEMISPHERE GLOBE on the flat surface show that if the earth were flat a person at the equator or even at the south pole could see another person at the north pole. Tacks may represent persons. Then, with the globe closed, show that, if the earth is round, a person south of the equator could *not* see another at the north pole, because the earth would rise up between them.

Illust. 3. The CELESTIAL SPHERE affords a good illustration. Place the observer on the equator, the North Star will then be in the horizon. If the earth were flat, the star would appear in the horizon as the person moved north. By moving the place of the person, and consequently his horizon, the North Star, or Pole, will be seen to rise above the horizon,* as is the case in traveling on the earth.

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* i. e., the horizon sinks below the North Star.

(In all illustrations with the Celestial Sphere, the person should be represented as standing on the top of the globe. This may be done by changing the inclination of the axis.)

Proof 5. Vertical lines at any considerable distance from each other are not parallel, but diverge toward different parts of the heavens.

A vertical line is a line perpendicular to the horizon.

1. If the earth was flat, all vertical lines would be parallel; *if round, they would diverge*, as they are found, by actual experiments, to do.

2. A horizontal line diverges from any horizontal plane surface. The divergence is eight inches for the first mile, 32, for two miles, 6 feet for three miles, etc.

Illustration. Insert two or more pins, perpendicularly to the surface of the globe, at some distance from each other, and they are seen to diverge outward and to converge toward the center, *i. e.*, are not parallel to each other, as they would be if inserted perpendicularly into a plane surface.

Apply a straight edge to the globe, and it is seen to coincide with it but a short distance.

(*Note.* A horizontal *line* must be straight; but a horizontal *surface* is not necessarily straight, or perfectly flat.)

Proof 6. If the earth was once in a fluid state, (and there is sufficient evidence to produce a general belief that it was,) the force of attraction would have compelled it to take the form of a sphere.

Illustration. Melted lead, dropped through the air, becomes round; e. g., shot. Water and quicksilver take the same form.

Proof 7. Analogy.

Remark. As all other bodies in the heavens are spherical, it is reasonable to conclude that the earth is likewise *a sphere.*

Proof 8. Actual measurement.

Remark. "From observations and actual measurements, mathematicians are able to compute the distances of places on the earth's surface, from its center; in numerous places, widely differing in latitude and longitude, these distances *have been computed*, and are found to be, in all instances, *nearly equal.* This fact proves the spherical shape of the earth, since a sphere alone, of all solid bodies, possesses the property, that the distance from the center to any point on its surface, is everywhere the same."—*Brocklesby's Astronomy.*

XIX. THE EARTH A SPHEROID.

That the earth is not a perfect sphere, but a spheroid, having the polar diameter shorter than the equatorial, appears from the following proofs:

Proofs that the earth is an oblate spheroid.
1. Varying vibrations of the pendulum.
2. Measurement of degrees of latitude.
3. Centrifugal force.
4. Analogy.

Proof 1. A pendulum vibrates more rapidly as it is carried from the equator towards either pole.

Remark. The frequency of the vibrations of a pendulum depends upon the force of gravity, and gravity varies inversely, as the squares of the distances from the center of the earth. Since then a pendulum vibrates more rapidly near the pole than near the equator, it is inferred that the surface at the pole is nearer the earth's center than at the equator, which would make the earth an oblate spheroid.

Proof 2. A degree of latitude on the earth's surface, as indicated by the stars, is longer near the poles than near the equator, showing that the surface is there flattened. This has been proved by measurement.

Remark. By accurate measurement of degrees in the torrid and frigid zones, the polar diameter is found to be twenty-six miles shorter than the equatorial diameter.

Proof 3. *Centrifugal Force.* If the earth was once in a fluid condition, and at the same time revolving on its axis with its present velocity, the centrifugal force would cause it to enlarge at the equator, and to become flattened at the poles. This is believed to have been the case.

Illustration 1. A ball of putty revolved rapidly on a wire, will take a spheroidal form.

Illust. 2. "If alcohol and water are mingled together, in such proportions as to have the same specific gravity as olive oil, upon dropping a little of the latter upon the mixed fluid, the drops of oil, uninfluenced by the gravitation of the earth, take the shape of spheres. But if now a slender wire is passed through the center of one of these *oil-globes*, and it is made to revolve by turning the wire rapidly round, it flattens about those points where the wire passes through, which represent the poles of the oil-globe, while it swells out at the middle, or equatorial parts, assuming the form of a spheroid, in consequence of the centrifugal force increasing from the poles to the equator." —*Brocklesby's Astronomy.*

Illust. 3. Pass a rod through the center of an India-rubber ball, and by means of machinery make it revolve rapidly. The ball will contract at its poles, and swell out at its equator, thus forming an oblate spheroid. The faster it revolves, the more oblate it becomes. When it ceases to move, it takes its original form, a sphere. A ring of tin in place of the ball, presents a similar appearance.

Proof 4. *Analogy.* Several of the planets are known to be oblate. The difference between the polar and equatorial diameters of Mars, is 88 miles; of Jupiter, 4,800 miles; of Saturn, 7,500 miles. The oblate shape of

Jupiter and Saturn can be plainly seen through the telescope. These planets are more oblate than the others, as they revolve on their axes with great rapidity. Though so many times larger than the earth they revolve in less than half its time

XX. MOTIONS OF THE EARTH.

The two most important motions of the Earth, are the diurnal motion, or that around its axis, and the annual motion, or that in its orbit around the sun.

Illustration 1. With the Globe on the stand, make it revolve on the inclination wire, or axis. This will represent the diurnal motion. If, at the same time, it is carried around any object representing the sun, it will illustrate the annual motion.

Illust. 2. The TELLURIAN affords a complete illustration of these motions. Care should be taken to mention that the orbit of the earth is not an exact circle, as represented by the Tellurian, though it differs but little from one.

Illust. 3. If the teacher has not the Tellurian, the best method of combining these motions is, to suspend the Globe, by a cord attached to a nail in the ceiling. By this means the elliptical form of the orbit may be shown, as well as the two motions combined.

Remark. The motion of the entire solar system round some unknown center in space, should be mentioned. After calling attention to the fact, that of all the stars we see, only four or five belong to our solar system; that the others are themselves suns, and may each be surrounded by its company of planets; give the opinion of astronomers, that as Jupiter, Saturn, Uranus, and

Neptune with their several moons, revolve with different velocities, round their common center the sun, so the vast multitude of suns, which to us seem only stars, with their systems of planets, revolve round some center common to them all, though to us unknown. The thought, by its sublime grandeur, can not fail to interest the pupil; the mind, reaching out to grasp it, will be expanded and will receive an impression of infinitude and omnipotence, never before felt. Even the mature and disciplined mind is filled with admiring awe by the thought; it seems but a short distance to look from nature thus revealed, "up to nature's God;" and the response is involuntary, "Surely, 'the undevout astronomer must be mad.'"

XXI. THE RELATIVE POSITION OF PLACES.

The true relative position of places is not shown on maps, except in comparatively small areas, and the globe should be in the hand of the teacher of geography at every recitation, in order that scholars may obtain the true direction and approximate distance of every country, state, or town, from their place of residence and from each other.

Remark. It will be seen by the globe, that any place, (as San Francisco,) may be said to be in three directions from any other place, (as London.) San Francisco can be reached by traveling in a continuous line on the earth's surface, either S. W. or N. E., or by electricity, in a straight line through the earth. Asia is both East and West of America, likewise, on the opposite side of the earth.

From the relative position of places on the earth's surface, the inhabitants receive different relative appellations.

1. ANTIPODES are those living diametrically opposite. They have opposite seasons, and opposite days and nights. ANTIPODES means opposite feet.

2. ANTŒCI are those living under the same meridian, but on opposite parallels of latitude. They have opposite seasons, but the same days and nights, though the days of one are equal to the nights of the other.

3. PERIŒCI are those living on the same parallel of latitude, but under opposite meridians. They have the same seasons, but opposite days and nights; *i. e.*, when it is noon with one, it is midnight with the other.

The ZENITH is the point directly over head, and is equally distant from all parts of the horizon.

The NADIR is directly under our feet.

XXII. UP AND DOWN, AND EAST AND WEST NOT ABSOLUTE DIRECTIONS.

Remark 1. *Up* and *down* are merely relative terms, meaning *towards* or *from* the earth's center. That direction, in space, or towards the stars, which is *up* at midday, is *down* at midnight. Or, if two persons are on opposite sides of the earth, the direction which is *up* to one, is *down* to the other.

Remark 2. *East*, is towards the point where the sun rises, and West is the opposite direction. But a person pointing either East or West, for twenty-four hours, points to every star in the heavens, upon the same parallel, and must necessarily point in as many directions, *in space*, as there are stars pointed at. But a person pointing *North* or *South*, for an entire day, points constantly to the same portion of the heavens.

Illustration 1. Insert two pins in the globe, at antipodes,

as in America and Asia. It will be seen that the heads point in opposite directions; *i. e.*, the direction which is *up* to one is *down* to the other. In this illustration, the globe may be held horizontally, as we never appear to be standing on the *side* of the earth.

Illust. 2. Revolve the globe, prepared as in Illustration 1, and the pins will be seen to point to all parts of the circle described by them; *i. e.*, up will appear to be in *all* directions in such circle.

Illust. 3. Place pins, as people, in different parts of the globe, and *up* will be seen to be *in different directions*, except at the pole, where it is always in the same.

Illust. 4. With the TELLURIAN arranged so the North pole of the earth, (where a pin may be inserted,) will point towards a fixed point in the room, turn the arm. The pole will continue to point in the same direction in all parts of the earth's orbit, showing that North and South are not variable directions.* Then insert a pin at the latitude of the pupil, or at the equator, and compare their changing direction, as the earth revolves, with the constant polar direction.

Illust. 5. WITH THE CELESTIAL SPHERE. Place pins in several different places, as Iceland, Newfoundland, Hayti, and Sicily. Move the brass band which supports the horizon place so the notch where the person is placed shall be at pin No. 1, and observe what part of the heavens is above him, or *up*. Move the person's place to pin No. 2, noticing, as before; and so on, to all the pins (or places) designated.

** It should, however, be stated that even the North and South poles of the heavens are actually changing, but so slowly that we consider them fixed.*

XXIII. SUCCESSION OF DAY AND NIGHT.

Illustration 1. By the Tellurian.—The succession of day and night is represented by placing a short lighted candle on the center of the large fixed pulley, in a darkened room, when half the globe will be seen to be in light and half in shade. Insert a small pin at your place of residence on the globe, and turn the globe on its axis with the finger, from west to east on the south side. It will be noticed that the place thus designated is alternately in light and shade, or in day and night. The succession of day and night is thus represented as it actually appears to an observer beyond the earth's orbit; say at Mars or Jupiter.

And, if the pin is supposed to be an observer, he will see the sun coming into view, (or rising,)over countries or seas at the east, and passing around over his meridian, disappearing (or setting,)behind countries and seas lying in the west.

Illust. 2. By the Celestial Sphere.—Insert a pin in the globe at any given point. Place the notch in the brass band of the horizon plane around the pin. The horizon plane then represents the real horizon of a person at that place. Place a light at a little distance, for the sun, and turning the globe and horizon plane, from west to east on the south side, the phenomena of sunrise, sunset, midday, and midnight will be more clearly presented than in any other way.

Illust. 3. By the Globe.—Insert a pin as before, placing round it a circular card paper, from three to six inches in diameter, and having a hole of half an inch in the center to represent the sensible horizon. The paper may

be fastened with other pins. A light should be placed near it, and the globe turned from west to east. The same appearances are presented as with the Celestial Sphere, except that they are confined to a small part of the earth's surface, instead of to one-half.

Remark.—In all the preceding illustrations by daylight, a window or any other object may be taken for the Sun, and the imagination can picture the illumined hemisphere on the side toward the supposed sun. It is better still to hold the globe *in the sunshine.*

XXIV. VARIATION IN LENGTH OF DAY AND NIGHT.

Illustration 1. By the Tellurian.—If the arm of the Tellurian, adjusted as already explained, be turned so as to bring the globe directly west of the yellow ball, or sun,* both poles will be illuminated by the light of the candle, as if proceeding from the Sun, and all parts of the globe, excepting the poles, will come successively and equally into light and shade, when it is made to revolve equally on its axis. At this point then in the earth's orbit, as well as at the opposite point, the days and nights will be equal all over its surface. Hence, the east and west points of the earth's orbit are called by astronomers equinoctial points or equinoxes, from *equus*, equal, and *nox*, night.

But, as the earth passes on in its orbit from the western equinox toward the south, since the axis continues directed toward the north, the light will gradually extend over the north pole and recede from the south pole. The northern

* When the words *Sun*, *Earth*, and *Moon*, begin with capitals they refer to the bodies in the heavens, but when they begin with small letters, they refer to the balls which represent them on the Tellurian.

hemisphere will thus become more than half illuminated, and the southern proportionally less. Now, it will be perceived that any place north of the equator will remain longer and longer in light at each diurnal revolution as the earth advances, until it arrives at the southern point of its orbit. Here the light will extend over the north pole twenty-three and a half degrees, and fall as far short of the south pole, giving the longest possible day to the northern hemisphere, and the shortest possible night; but, in the southern hemisphere, the shortest day and the longest night.

Notice, too, that all places north of the Arctic Circle will make more than one entire revolution in light, and thus have a day of more than twenty-four hours in length.

Again, turn the arm and carry the globe through the northern part of its orbit, it will readily appear why the inhabitants of the northern hemisphere have nights longer than days in that part of the earth's orbit.

That both poles must have days and nights of six months each, is also apparent.

Illust. 2. By the Celestial Sphere.—Place the notch in the brass band of the horizon plane opposite any given day, as marked on the upper edge of the zodiac, e. g., the 20th of March. That portion of the globe on the sun's side of the horizon plane will have day, the other part night. If desired to find the length of the day at any place on the earth on that day, find the latitude of the place on the globe, and on that parallel count the number of meridians between the eastern and western horizon. This will give the number of hours in the day.*

* Twenty-four meridians are drawn on this globe, and each one answers to one hour of time.

Subtracting that from twenty-four hours will of course give the length of the night. In this case, as will be seen, the sun shines from pole to pole, and days and nights are of equal length on all parts of the earth.

Illust 3. Move the middle of the horizon band under the sun's place in the ecliptic, on the 20th, or any other day, of April. It will be seen that the sun then shines beyond the North pole, and not quite to the South pole. By counting the meridians, it will be found that South of the equator, the days are less than twelve hours, and longer North of it. The same illustration will answer for any day in the year.

Remark 1. To find the length of the day when the sun is in the Southern part of the ecliptic, the center of the horizon band must be placed opposite the corresponding month and day in the Northern part of the ecliptic. The horizon plane shows the day and night as before, but as the sun is on the opposite side of it, so day must be on the opposite side of the globe.

Remark 2. To find the time of the sun's rising, take half the length of the night; half the length of the day will give the time of its setting.

PROBLEM. *To find where the sun does not rise, and where it does not set, on any given day.*

WITH CELESTIAL SPHERE. Place the notch in the middle of the horizon band under the ecliptic, at the point marked on the upper edge of the Zodiac, for the given day. Keeping the horizon plane in this position, revolve the globe. The sun will not rise to those parts of the globe which do not appear above the horizon; and it will

not set to those parts which remain above the horizon when the globe is revolved.

Note. When the notch in the center of the horizon band of the Celestial Sphere, is placed directly under the sun's place in the ecliptic, the horizon plane will represent the dividing line between day and night, since the sun will be visible to all places on one side of this plane, and invisible to all on the other side.

XXV. APPEARANCE OF THE SUN AT THE POLES.

About the 21st of March, the sun begins to be seen. This is the first sunrise for months, and without coming entirely above, it moves *around* the horizon. At each such revolution, or day of twenty-four hours, a larger portion of the sun rises above the horizon, until its whole disk is seen passing round and round, never setting, but rising higher and higher in the heavens, till, by the 21st of June, it has reached its highest point, which is twenty-three and a half degrees above the horizon. The sunrise has now continued three months. From this time the sun makes its revolutions as before, except that it seems now gradually *sinking*, till the 23d of September, when it entirely disappears, having been visible at the North Pole for six months. At the South Pole the same phenomena will now occur during the next six months, while the North Pole will be in darkness.

Note. It should be stated that the appearances, as here described, are much modified by refraction of the rays of light, owing to the denser atmosphere of the poles. The teacher can add much to the interest of the class, by mentioning the effect of the Aurora Borealis, and twilight, in the Frigid Zones, and giving, or encouraging pupils to collect information obtained by the various Arctic navigators.

"From what has been stated, it appears that within the polar circle there are long intervals of day and night, while at the poles themselves, there is but *one day* and *one night*, each of *six month's duration*. But several causes exist which tend to

shorten the dreary winter of the frigid zones. The principal of these are *refraction* and *twilight*. The refraction in these regions is *unusually* great, causing the sun to *appear above* the horizon, when it is *really considerably below it*, and of course *shortening the night*.

In the year 1597, three *Hollanders* were compelled to pass the winter at *Nova Zembla*, in *N. Lat.* 75½°. After a *night* of *three months* duration, the sun appeared on the horizon, in the south, *fourteen days sooner* than they expected it in *this latitude*, and continued from this time to rise higher and higher in the heavens. If the sun, in this instance, appeared *fourteen days before* it was *really due*, the refraction must have been equal to *three and a half degrees*.

Twilight is chiefly caused by the irregular reflection of the sun's rays from the particles of the atmosphere, when the orb is below the horizon; and it ceases when the sun is below the horizon *more than eighteen degrees, measured* on a *vertical circle*. At the *equator*, where the circles of daily motion are perpendicular to the horizon, the twilight is the *shortest*, and continues only an *hour* and *twelve minutes*.

The *inclination to the horizon* of the sun's *apparent daily path*, affects the duration of the twilight. In all countries *situated between the equator* and the *poles*, the *longest twilight* occurs at the time of the *summer solstice*. In *latitude* 42° 23′ 28″, the longest twilight lasts for the space of *two hours, twenty minutes*, and *thirty-one seconds*.

At *either pole*, the sun, in its apparent path, moves *parallel to the horizon*, and never sinks more than about 23½ degrees below it; but until it has passed lower than 18°, the faint glimmerings of twilight do not forsake even these places. The combined effect of *refraction* and *twilight*, in shortening the *polar night*, is so great that at the *very poles*, its duration is only *seventy days*, instead of *six months*, and even the obscurity that then prevails is relieved by the constant presence of the *moon*, when it passes north of the equator; and likewise by the frequent and fitful splendors of the *northern lights*." (*Brocklesby's Astronomy.*)

Illustration 1. WITH THE TELLURIAN. Fasten a circular card, (two inches in diameter,) to the earth, by inserting a small tack at the North Pole. The tack and card will represent a person and the plane of his horizon.

With the instrument properly adjusted, turn the arm till the "*Winter Solstice*," marked on the large fixed pulley, is under the yellow ball, or sun. Standing opposite the sun, look along this card, *i. e.*, horizon. The sun will be hidden below it, as is the case in winter. Turn the arm till the "*Vernal Equinox*" comes under the sun, *i. e.*, the sun is in the vernal equinox. By looking along the horizon as before, the *upper portion* of the sun is visible. Keeping the arm stationary, and the eye on a level with the card, turn the *standard* in the *opposite direction from the motion of the arm*, *i. e.*, toward you.

(This, of course, will produce the same relative changes of position of sun and earth as if the arm were moved.)

As the earth revolves on its axis, the sun will be seen to be always above the horizon, and at every revolution to rise higher, till the sun reaches the "Summer Solstice." From that point it will appear to descend, till the sun is in the "Autumnal Equinox," when it disappears.

Illust. 2. With the Celestial Sphere. Place the horizon band so as to represent a person at the North Pole. Hold something, (e. g. a wafer,) just above the edge of the ecliptic, to mark the sun's place on the 21st of March. It will be nearly level with the horizon. Revolve the globe, *with the horizon* plane. The sun will not go below the horizon. After one revolution, move the sun's place on the ecliptic, (one day will make but little difference, and it may be moved ten, twenty, or thirty days,) to the 21st of April. It will be plainly seen that it is now considerably above the horizon. Revolving the earth and horizon plane will present the sun's appearance on that day. Carry the sun round the ecliptic, gradually,

to the 23 of November, when it sinks below the horizon, *i. e.*, sets.

SUN AT DIFFERENT POINTS.

The appearance of the sun will be changed as we go from the *Poles toward the Equator*.

Illustration 1. On the 21st of June, when the sun is highest at the North Pole,—*i. e.*, 23½ degrees above the horizon—to a person at the latitude of 80° N., it will appear *at midday*, 33½ degrees above, and twelve hours later *i. e.*, midnight, it will be *only* 13½ *degrees* above the horizon.

(This may be illustrated by the Tellurian, with the card placed at latitude 80°, and used as described in XXV—1. Better still by the Celestial Sphere, as in XXV—2.)

Illust. 2. At the same date, to a person at the arctic circle, the sun, at midday, would be 47 *degrees* above the horizon, and would go *round*, gradually sinking, till when directly *North* of the spectator it would *set*. In a few minutes it would begin to rise, and rising gradually higher as it goes round, would again reach 47 degrees at noon of the next day.

(The two instruments above named and especially the Celestial Sphere, give excellent illustrations of this.)

Illust. 3. On the same day, a person at 23½° N. latitude, would see the sun rise at 6 o'clock, precisely East; at noon it would be directly over head, and would set at 6 o'clock, exactly West.

(Illustrate by Tellurian and Celestial Sphere, as above.)

Illust. 4. To a person at the antarctic circle, on the same day, (June 21st,) the sun, which has for three months been gradually descending, would be seen to rise,

(*i. e., one edge of it would appear*) *about noon,* very near the south point of the horizon, and moving only a little way past the south point, would set. The whole of the sun would not be seen, and there would be but an hour or two from sunrise to sunset. The South Pole, on that day, would be in the middle of their long winter of six months.

(Illustrate by Tellurian and Celestial Sphere.)

Remark 1. With the Celestial Sphere, by turning the *globe and horizon plane,* the path of the sun in the heavens, place of its rising and setting, and length of the day or night at any day in the year, may be clearly shown. *See Sections XXIII and XXIV.*

Remark 2. From these illustrations, it will be easy to explain why the sun, in summer, shines in at the windows on the North side of a house, a short time after sunrise, and before sunset. For as we go North, the sun rises nearer to the North point of the horizon, and at the arctic circle, on the 21st of June, it rises *in the North.* At the antarctic circle, the reverse of this will happen.

XXVI. CHANGE OF SEASONS.

The changes of the seasons depend on the comparative lengths of day and night, and on the height of the sun above the horizon. The longest day occurs when the sun is farthest above the horizon. These two causes produce the warm season, or Summer, and are themselves the result of the inclination of the Earth's axis to the plane of its orbit, and the invariable parallelism of this inclination in all parts of the Earth's orbit.

This inclination is represented by the globe, and also by the

earth of the Tellurian. The Tellurian also shows the parallelism of the inclination.

The inclination of the earth's axis, together with its parallelism, influences more or less all terrestrial phenomena. The attentive pupil must have already seen that the variation in the length of day and night is the result of this cause. If so, he is prepared to understand in what manner the change of seasons is brought about by the same means.

Illustration 1. WITH TELLURIAN. Let the arm of the Tellurian be directed toward the south, then the earth's axis will be inclined toward the sun, and a line extending from the earth's center to the sun's center, will pass through the tropic of Cancer.

Illustrate this by a string stretched from earth to sun.

Hence, when the sun and earth are in this position with regard to each other, an observer on the Tropic of Cancer, at noon, would see the sun directly over head, and all the inhabitants of the Northern temperate and frigid zones would see the sun at its greatest altitude. This must be MIDSUMMER, or as it is termed by astronomers, the Summer Solstice. The longest day occurs at this time, in the Northern hemisphere, and the sun is more nearly vertical when on the meridian, at all places North of the tropic of Cancer, than at any other time of the year; *i. e.*, the sun shines a larger portion of the twenty four hours on this part of the earth's surface, and emits a larger amount of rays on any given space, than at any other time.

Illust. 2. Move the arm from South to East. As the inclination of the axis continues toward the North, it

becomes less and less inclined toward the sun as the earth moves on to the Eastern part of its orbit. Being at the Eastern point, it is neither inclined to nor from the sun, but the extremities, or poles, are equally illuminated. As before shown, this is one of the equinoxes, and as it succeeds summer, it must be the Autumnal Equinox, or Autumn. The sun is now vertical at the equator, or "crossing the line," and consequently gives less heat at places North of the equator. The days and nights are now of equal length at all places on the earth.

Illust. 3. Again, turn the arm from East to North. Observe that the North pole is carried into darkness, while the South pole is brought more and more into light. When the earth has reached the North point of its orbit, the axis is inclined away from the sun, and the Southern hemisphere is more directly under its influence. The Sun will now be vertical at the tropic of Capricorn, and shine a longer portion of the twenty-four hours on the Southern hemisphere, and with greater intensity; while the days are shorter, and the rays more oblique on the Northern hemisphere than at any other time of the year. Here, then, must be the Winter Solstice, or WINTER, to the inhabitants of the Northern hemisphere.

Illust. 4. Carry the arm from North to West. Observe that the days become longer and longer in the Northern hemisphere, while the earth is performing this part of its annual journey. The globe having arrived at the West point of its orbit, occupies the same relative position with regard to the *light*, as the Earth with regard to the Sun, at the vernal equinox. The Sun is now visible at both poles, and is again crossing the line.

Remark 1. Thus having followed the round of the seasons, we can not but admire the simplicity of the mechanism which produces such varied and beautiful results. Were the axis perpendicular to the plane of the orbit, there could be no change of seasons, but constant burning heat would prevail in the equatorial regions, while perpetual ice would cover a much larger portion of the earth's surface than under the existing arrangement.

Remark 2. The tropics are so named because at these lines the sun appears to turn to go back to the equator. *Tropic means a turning.* Their places depend upon the inclination of the earth's axis, being necessarily as many degrees from the equator as the axis is inclined from the perpendicular. Were the axis to lie down on the plane of the orbit, there would be no tropics.

The axis of Mars is inclined about 28½ degrees.
" " Jupiter " " 3 "
" " Saturn " " 27 "

Consequently Mars and Saturn have changes of seasons similar to our own.

[The following cut and explanation, taken from Brocklesby's Astronomy, affords additional illustration and information on this subject, and will be especially valuable to teachers.]

"By the aid of Fig. 19,* we shall be enabled to perceive how the variety of the seasons is produced by the causes just mentioned. In this cut, S^1 represents the sun, the *twelve globes* indicate the several *positions* of the earth in its orbit, in the successive *months of the year*, with the *corresponding signs;* and the dotted line C S^1 C, gives the *direction* of the *plane of the ecliptic.* In the several globes, C is the center of the earth, D C L is an equatorial diameter, and shows the *direction* of the *plane* of the *equator ;* the diameter at right angles to this, viz.: N C S is the *axis* of the earth, and its extremities the north and

*The figure is drawn as if the plane of the ecliptic was viewed obliquely, consequently the orbit of the earth appears more eccentric than it actually is.

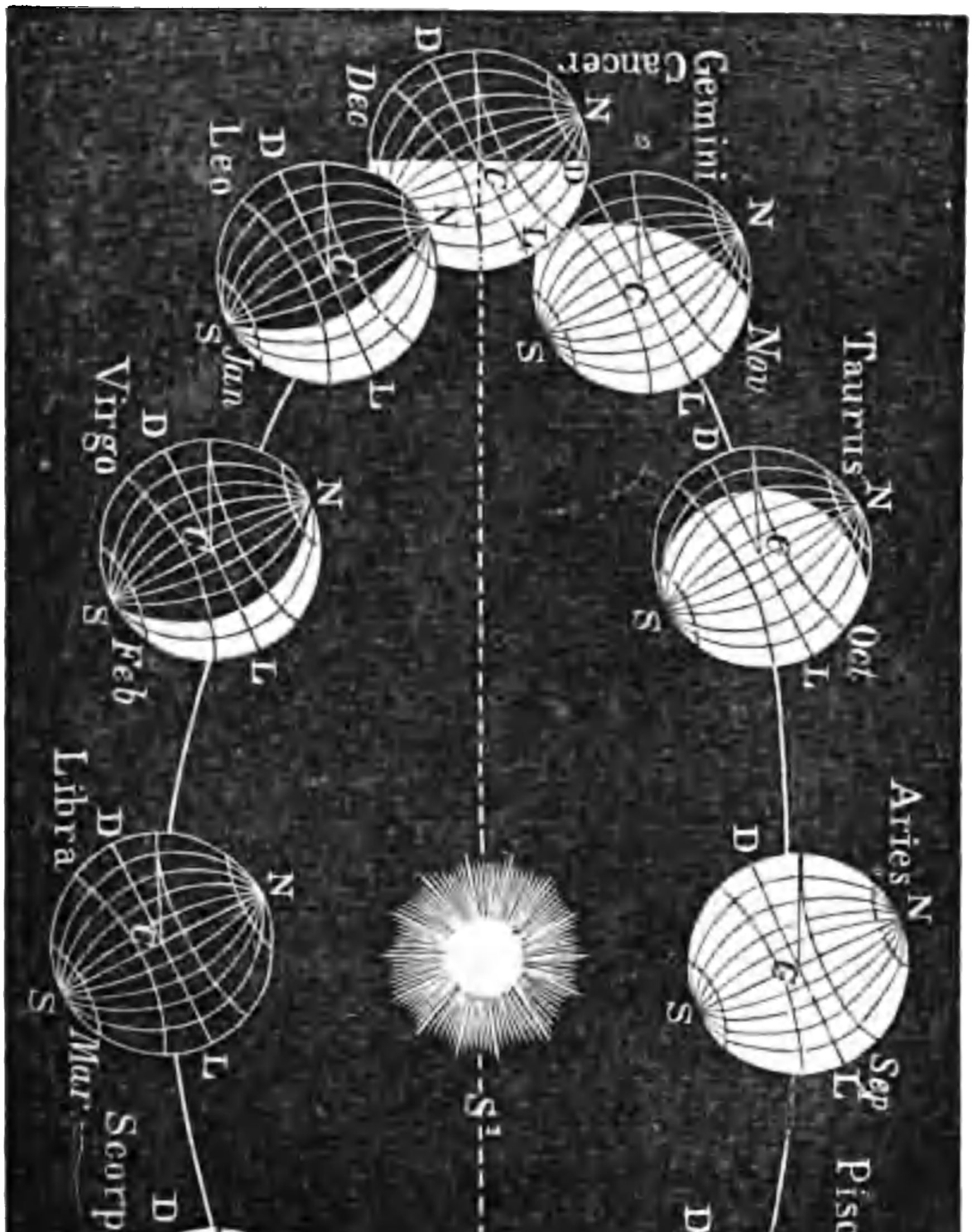

FIG. 19.

south *poles ;* N representing the north pole. The two large arcs of circles on each of D C L, are the tropics, and the small arcs near the poles the *arctic*, (northern,) and *antarctic* (southern,)

polar circles. The lines drawn in each globe from C, parallel to C S¹ C, indicate the position of the *plane* of the *ecliptic* with respect to that of the *equator*.

"SPRING. At the *vernal equinox*, (March,) when the earth is in Libra,* the *circle of illumination* extends to the two poles,† the sun is in the plane of the equator, and is seen from the earth in this plane. As the earth rotates on its axis, every point upon its surface is then *half the time of one rotation*, in darkness, and *the other half in light*. In this position of the earth, the days and nights are therefore *equal* all over the globe.

"SUMMER. When the *earth* is in *Capricorn*, at the northern summer solstice, (June,) the axis being unchanged in direction, the north pole is presented toward the sun, and the circle of illumination *extends beyond the pole*, N, to the *arctic* (northern) *circle*, while in the *southern hemisphere*, it *falls short* of the *south pole*, S, reaching only to the antarctic (southern) circle.

"The exact distance that the circle of illumination now *overlaps* the *north*, and *falls short* of the *south* pole, is equal to the *obliquity* of the *ecliptic*, (*i. e.* 23½ degrees.) * * * The parallels of latitude, therefore, to which the circle of illumination extends, at the summer solstice, and which are termed the *arctic* and *antarctic* circles, are each about *twenty-three and a half degrees* from their respective poles. The regions inclosed within these circles, are called the *frigid zones*.

"At the time of the northern summer solstice, *continual day* reigns at all those places that are situated *within the arctic circle*, inasmuch as the daily rotation of the globe does *not carry them without the circle of illumination*; while over the regions that lie within the *antarctic circle*, an *unbroken night* prevails, because the earth, in its rotation, does not, at this time, *bring them within* the circle of illumination. It is evident from an inspection of the figure, that in the *northern hemisphere* the days will increase in length, and the nights decrease, from the equator to the arctic circle, where there exists a *continual* day. In the *southern hemisphere*, the *days* will *decrease*, and the *nights increase* in length, from the equator to the *antarctic* circle, where an uninterrupted *night* prevails.

"At the vernal equinox the days and nights, as we have seen,

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* At the time of the vernal equinox the earth is in Libra, but the sun, *as viewed from the earth*, appears on the *opposite side* of the heavens, in the sign Aries.

† In the figure, at the *vernal equinox*, the *dark hemisphere* of the earth is presented to our view, the illuminated hemisphere being *toward the sun*, as shown in the globe at Aries. The *circumference* of the circle of illumination both at Libra and Aries, is D N L S.

are *equal* in length. A difference in this respect commences as soon as the earth departs from this point, which gradually increases up to the time of the *summer solstice*, when the difference in the lengths of the days and nights is greatest.

"AUTUMN. As the earth departs from the northern summer solstice, and by degrees comes round to the *autumnal equinox*, (September,) the circle of illumination gradually approaches the poles, *shortening* the days and *lengthening* the *nights*, in the *northern hemisphere*, and producing the *contrary effects* in the *southern*. When the earth has arrived at the autumnal equinox, in the sign Aries, the circle of illumination again passes *through both poles*, and the days and nights are once more *equal* in length.

"WINTER. The earth, moving onward in its course towards the *northern winter solstice*, the circle of illumination also changes its position, *falling short* of the north pole more and more, and gradually *extending beyond* the south pole, increasing the duration of the *nights* in the northern hemisphere, and *diminishing* that of the days; while in the southern hemisphere the opposite effects are produced. At the winter solstice, when the earth is in the sign Cancer, (December,) this change has reached its full extent; the circle of illumination then reaches *beyond the south pole*, to the antarctic circle, and the regions within this circle now enjoy a *continual day*. But in the northern hemisphere, the circle of illumination extends *only to the arctic circle*, and the space *within* the latter is now overshadowed by a constant *night*.

"As the earth withdraws from the northern winter solstice, and again returns to the vernal equinox, the circle of illumination, by degrees approaches the poles, and the differences between the lengths of the days and nights grow less and less, till they cease to exist, when the vernal equinox is attained.

"We must bear in mind, in this explanation, that the *winter* of the northern hemisphere is the *summer* of the southern, and the winter of the *southern* hemisphere, the summer of the northern."

XXVII. TRADE WINDS.

These winds are so named from the advantages they afford to trade, by facilitating commercial intercourse They are produced by two causes, viz.:

1. The current of air flowing toward the equatorial

regions, to supply the place of the air which there rises by reason of the sun's heat.

2. The revolution of the earth on its axis.

Illustration. WITH THE GLOBE. It is supposed that the sun is shining directly on the equator. Those parts of the earth's surface about the equator, being much heated, rarefy the air in contact with them. The air thus rarefied rises; other air from the north and south, within and beyond the tropics, flows in to supply the place of the air so elevated. But as the atmosphere partakes of the motion of that part of the earth's surface with which it is in contact, and as the surface at the tropics and beyond them, does not move as rapidly, from west to east as at the equator, since those circles are smaller than the equator, it is plain that if air with the eastward motion of the tropics, say 900 miles an hour, were instantaneously transported to the equator, where the eastward motion of the earth's surface is 1,000 miles an hour, the air so transported would have a relative backward, or westward motion, of 100 miles an hour. But as it is not transported instantaneously, but flows with a moderate velocity, its westward motion, though considerable, is not so great. It must be remembered that the motion toward the equator is combined with the backward or westward motion, giving the Northern trade winds a direction toward the South West, while the Southern trade winds blow toward the North West. When the two currents meet, which is always a few degrees behind the sun, in its course from one tropic to the other, they combine and form a westerly current.

XXVIII. SIDEREAL AND SOLAR DAY.

The SOLAR DAY is the time from *noon* of one day, to *noon* of the next day, or the interval between the moment the *Sun* is on the meridian, *i. e.* over head, in any place, and the time when it is *next* on the same meridian.

The SIDEREAL DAY is the interval between the moment a *star* is on the meridian of any place, and the time when it is *next* on the same meridian. The solar day is about four minutes longer than the sidereal.

The earth performs *one exact revolution* on its axis, in a *sidereal* day.

FIG. 20.

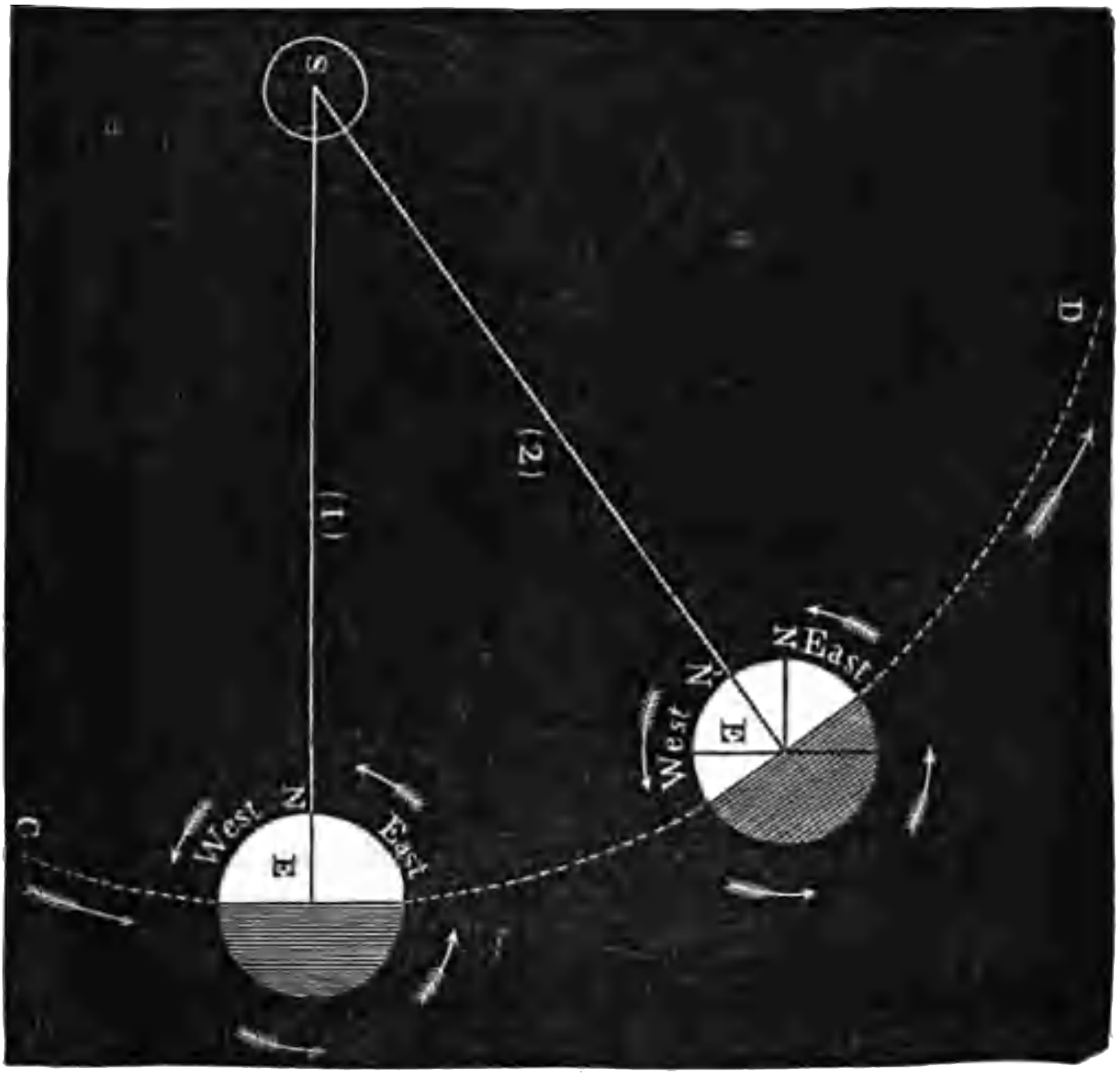

Illustration 1. This subject is illustrated by the preceding diagram, which, with the explanation, is taken from Brocklesby's Astronomy.

In this figure, "S represents the sun, and E, E, the earth in two positions of its orbit; the *dark* semicircles are sections of the unenlightened hemisphere, and the *light* semicircles, sections of the enlightened hemispheres. In position (1) it is *noon* at N, because there are equal portions of the illumined hemisphere on the east and west side of it. But on the next day, when the earth has made *one complete rotation*, i. e. the sidereal day, and has in the meanwhile also moved along in its orbit, C D, to position (2,) it will *not* then be *noon* at N, for the meridian plane *now* passes through N^1; the earth will have to revolve on its axis until N has arrived in the position N^1, before it will be noon at N, and the time occupied in describing the arc, $N N^1$, will be the excess of the solar above the sidereal day."

Note. In a year there are 366 *sidereal* days, but only 365 1-4 *solar* days.

Illust. 2. WITH TELLURIAN. Let the arm of the Tellurian be directed toward the north; insert a pin at any point on the equator of the globe; let the pin be directed toward the sun, (yellow ball,) which will be exactly south. Now turn the globe once on its axis, by moving the arm forward a short distance toward the west. When the pin is brought around again toward the south, it is not directed toward the sun as before, but must make a part of another revolution to come round in the direction of the sun. The first is the sidereal the south point representing a fixed star, the second is the solar revolution—or day. There will, of course, be one more sidereal revolution than solar in a year, however few or many there may be of either, unless the revolutions are in opposite directions, when there will be one less.

Illust. 3. WITH CELESTIAL SPHERE. Suppose the sun to be at the beginning of the sign Taurus. It is then

the first day of April. Insert a pin at one of the meridians marked on the globe, and place it directly under the sun's place in the ecliptic. Suppose a star also to be directly above the sun's place. Revolve the globe once and the pin will point again to the first point of Taurus. The star will also be there, and directly over head to the pin, or person. But the sun *has moved one degree* further east, in the ecliptic, and consequently is not exactly over head; and the globe must be revolved a *little further*, to make it noon by the sun.

Note. If the distance for one day is too small to be clearly seen, revolve the globe ten times to the same star, and the difference between this and the sun's place ten days later will be obvious.

Illust. 4. WITH GLOBE. Call some object at a short distance the sun, and insert a pin in the globe, pointing toward that object. Turn the globe once on its axis; the pin will point toward the sun. Then explain that the earth moves forward in its orbit, constantly, and move the globe around, to represent such motion. The pin no longer points to the sun, but the globe must revolve still further, or *more* than once round, to make the solar day.

Note. This illustration is imperfect, inasmuch as any object representing the star will be so near that the pin will not, at all times, point directly toward it, at the end of one revolution. But if the object representing the sun is placed at a distance of *two feet*, and the star *across the room*, the difference between the revolutions will be sufficiently clear.

XXIX. ABSOLUTE AND RELATIVE TIME.

It is considered 12 o'clock, M., at any place on the earth's surface when the sun is on the meridian of that place.

But as the sun has an apparent motion from east to west of 15 degrees an hour, or 360 degrees in 24 hours,

evidently, it can not be 12 o'clock at the same time, at any two places not on the same meridian.

Then at any place, as Boston, lying on a meridian east of any other place, as New Orleans, it must be 12 o'clock, or noon, before it is noon at the latter place, because the sun will reach the meridian of Boston sooner, in its westward course, than it will the meridian of New Orleans.

Hence, if it is noon at Boston, it will be *forenoon* at New Orleans, and if it is noon at New Orleans, it will be *afternoon* at Boston. While then absolute time is the same in all places, relative time is *later* at places lying *east* of us, and *earlier* at places lying *west* of us.

Illustration 1. WITH GLOBE. Insert a pin at Boston, another at New Orleans, assuming any object on a horizontal line with the globe for a sun. Turn the globe on its axis, from west to east, it is seen that the pin at Boston points to, or comes under the assumed sun before the pin at New Orleans.

Remark. There are twenty-four meridians marked on the globe, equal to the number of hours in a day. The distance between any two of them is equal to one hour of time. Hence, count the meridians between any two places on the globe, and you have the number of hours difference in relative time. The globe of the Tellurian may be used as above.

Illust. 2. WITH CELESTIAL SPHERE. Insert pins in the globe, as directed in Illust. 1. Fix on any point in the ecliptic for the sun's place, and proceed as in first Illustration.

PROBLEM. *When it is noon of a given day, at any given place, to find all places where the sun is rising or setting.*

Place the notch in the horizon band under the given day, as marked on the zodiac. Turn the globe till the meridian passing through the place given, shall also pass through the notch in the horizon band. Then at all places under the edge of the horizon plane, it will be sunrise *or* sunset. At the eastern edge it will be sunset, and at the western, sunrise. At *all* places on this meridian and above the horizon, it will be noon.

Remark. The time at intermediate places may be found by counting the meridians, allowing one hour for each meridian. Going east from the given place, the time will be later, and west, earlier than noon.

XXX. THE MOON.

REVOLUTIONS.

The Moon has at least three revolutions: the first on its axis, the second around the earth, the third around the sun.

The Tellurian represents the Moon as presenting always the same side to the earth. This is true to nature, and it gives the moon one revolution on its axis for each revolution around the earth, as, obviously, all sides of the moon will be brought successively under the eye of an observer situated beyond the moon's orbit.

CHANGES OF THE MOON.

The changes of the moon are the result of its opacity, and its revolution about the earth. We have new and full moon one in twenty-nine and a half days, because its revolution around the earth once in twenty-eight days, in connection with the common motion of these bodies

around the sun, brings them all into *the same relation* with regard to each other in that period of time. This period is called a *lunation* or *lunar month.**

The moon, like the earth, shines only by reflecting the light of the sun. Hence, that side of the moon which is turned toward the sun is light, while the other is dark. At NEW MOON the moon is between the earth and sun, consequently the bright side is toward the sun, and the dark side toward the earth. At this time the moon rises and sets *with the sun;* but, as its light shines *away from the earth*, we cannot see it.

In a few days it advances so far east of the sun that it sets later than the sun, and is visible in the west immediately after sunset. At this time only a small part of the bright side is toward the earth, and appears of a crescent form. (*Illustrate by Tellurian.*†) Each day the moon moves further from the sun, and the bright part increases till when one-fourth of her revolution is completed, the half moon or FIRST QUARTER is presented to view. And, at half the monthly revolution, the entire bright side is toward the earth, giving us the rich beauty of the FULL MOON. The moon and sun are now in *opposition.* (*Illustrate by Tellurian.*)

From this time the bright portion grows smaller daily, as if crescents were daily *cut off* from one side; and, at the end of another week, a half moon is again seen, and the moon is in her THIRD QUARTER.

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* The difference of a sidereal and a synodical revolution can be shown in a manner similar to that of illustrating the difference between a sidereal and solar day.

† Half of the moon should be blackened. Some have not been made so, but can be colored with a pencil or ink.

TELESCOPIC APPEARANCE OF THE MOON IN QUADRATURE.

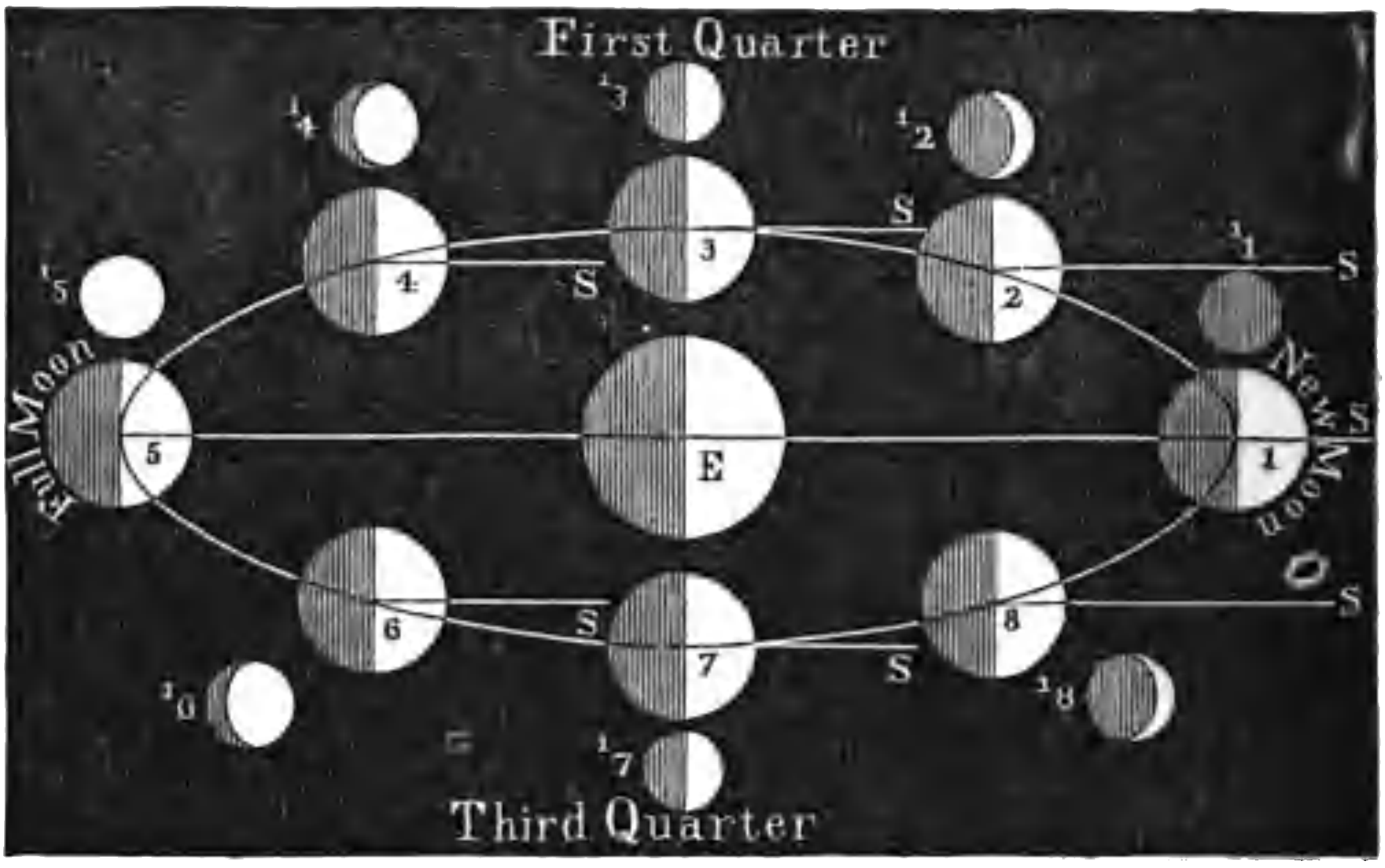
FIG. 81.

The enlightened half now appears to be *hollowed out*, little by little, daily, as the moon approaches nearer the

sun until they are in conjunction again. The old moon has disappeared, and the new moon is invisible.

The following figure gives a view of the positions and phases of the moon.

FIG. 22.



"S 8, and S 1, and all lines parallel to these, indicate the direction in which the sunbeams come, and E represents the earth. The circles 1, 2, 3, 4, 5, 6, 7, and 8, show the places of the moon in her orbit; at *conjunction* (1,) the *first octant* (2,) the *first quarter* (3,) the *second octant* (4,) *at opposition* (5,) the *third octant* (6,) the *third quarter* (7,) and the *fourth octant* (8;) while the *white portions* of the circles 1^1, 2^1, 3^1, 4^1, 5^1, 6^1, 7^1, and 8^1, exhibit the *phases* of the moon in all the preceding positions. Thus, when the moon is in the *first octant* (2,) the *phase corresponding* to this place is displayed in circle 2^1, that of the *first quarter* (3,) in circle 3^1; and so of all the other positions."—(*Brocklesby's Astronomy.*)

Remark 1. The *new moon* rises with the sun; the first quarter rises at noon; the full moon rises at sunset; and, the third quarter at midnight.

Remark 2. The horns of the crescent are always turned away from the sun.

Illustration 1. Placing a light on the Tellurian, in front of the sun, turn the arm so as to bring the moon between the sun and earth. The dark side of the moon is now toward the earth, and this is the position of the three bodies at *new moon*, or when the sun and moon are in conjunction.

Illust. 2. Turn the arm again, and bring the moon around on the side of the earth opposite the sun. The illuminated side of the moon is now presented to the earth. This is *full moon*, and the sun and moon in this position are said to be in *opposition*. As the Moon's orbit is not on the same plane with the earth's orbit, the moon is sometimes above and sometimes below the plane of the earth's orbit or *ecliptic* when new or full. Hence, we do not always see exactly the same hemisphere at full moon, or the crescent pointing in the same direction at new moon. The horns of the crescent will, however, always point away from the sun whether above or below; or, as we say, the moon *runs high* or *runs low*; all of which can be clearly shown by the Tellurian.

The intermediate phases, as the quadrants and octants, are also shown by the Tellurian.

HARVEST MOON.

The moon's advance in her orbit causes her to rise about 50 minutes later each day. But, in the North Temperate Zone, during the months of September and October, the moon rises only from 18 to 25 minutes later each day. As the full moon in these months rises, for several days in succession, nearly the time of sunset, and thus lengthens out the days when the farmer most needs long days to secure his crops, it has been called the

Harvest Moon. This difference is caused by the moon's orbit being more inclined to the horizon at this time than at any other. As the moon's orbit differs but five degrees from the ecliptic, the latter, which is well-known, will suffice for illustration. In our latitude (40°) as much of the ecliptic about Pisces and Aries rises in two hours as the moon goes through in five or six days; hence, the moon, while in these signs differs but two hours in rising for that time, or about twenty minutes per day.

The moon when full is in *opposition* to the sun. Hence, when the *full* moon is in Pisces or Aries, the sun is in the opposite signs, viz.: Virgo or Libra; and the sun is never in Virgo and Libra, except in the months of September and October; consequently, these will be the *only* full moons in the year which rise, for nearly a week in succession, about the time of sunset.

In September it is called HARVEST MOON, and in October HUNTER'S MOON.

Remark. The moon actually rises with as little variation for one week of *every month*; but, when it does not occur at *full moon*, is not noticed.

Illust. 1 WITH CELESTIAL SPHERE.—Let the observer on the horizon band be placed at 60° north latitude. Then hold the sphere so that Virgo of the ecliptic will be toward the eye, or the scholar, and *above the horizon.* Now turn the globe, and horizon with it, from west to east, till the western edge of the horizon intersects the *lower* edge of the ecliptic at the 180°, or the last of Virgo. In this position, one of the meridians on the globe will be hid by the brass meridian of the sphere. Now, move the globe and horizon from

east to west till the next meridian on the globe is hid by the brass meridian. The horizon will now intersect the ecliptic at 150°, or the *first* point of Virgo; i. e., *one sign will have risen above the horizon in one hour.* Again hold the sphere so that *Cancer* shall be toward the eye, and the horizon intersect the ecliptic at 120°. Move the globe westward, as before, one degree, and the intersection will be at 100°; or, *only two-thirds of a sign* will have risen in an hour. Showing that if the moon when in Cancer rose one hour later each day, in Virgo it would rise only 40 minutes later, thus making the Harvest Moon.

Note. This illustration is imperfect, owing to the limited distance of the ecliptic—which represents the moon's orbit—from the earth, it being as here represented about half the earth's diameter, (or 4000 miles) instead of 240,000 miles.

XXXI. ECLIPSES.

An eclipse is simply a darkening, or concealment of the sun, or moon, by the interception of the sun's rays. While they are among the most interesting phenomena to all classes of observers, eclipses have also proved of essential service in advancing science.

ECLIPSES OF THE SUN.

When the moon, passing round in her orbit, comes between the sun and the earth, a portion of the sun must be *hid* from the view of persons on the earth, in the same way that a ball or a book, held between the eye and the sun, would hide the sun, either wholly or in part. This is an *eclipse* of the sun.

A Total *Eclipse* is when the sun is entirely concealed.

A PARTIAL *Eclipse* is when only a part of the sun is concealed.

An ANNULAR *Eclipse* is when the *center* of the sun is concealed, but its outer portion is seen around the edge of the moon, like a ring of light. This is caused by the moon's being further from the earth than at the total eclipse, otherwise this would also be *total*; as a ball or book held near the eye would entirely conceal the full moon, but if held at a greater distance would allow the edge of the moon to be seen entirely round it.

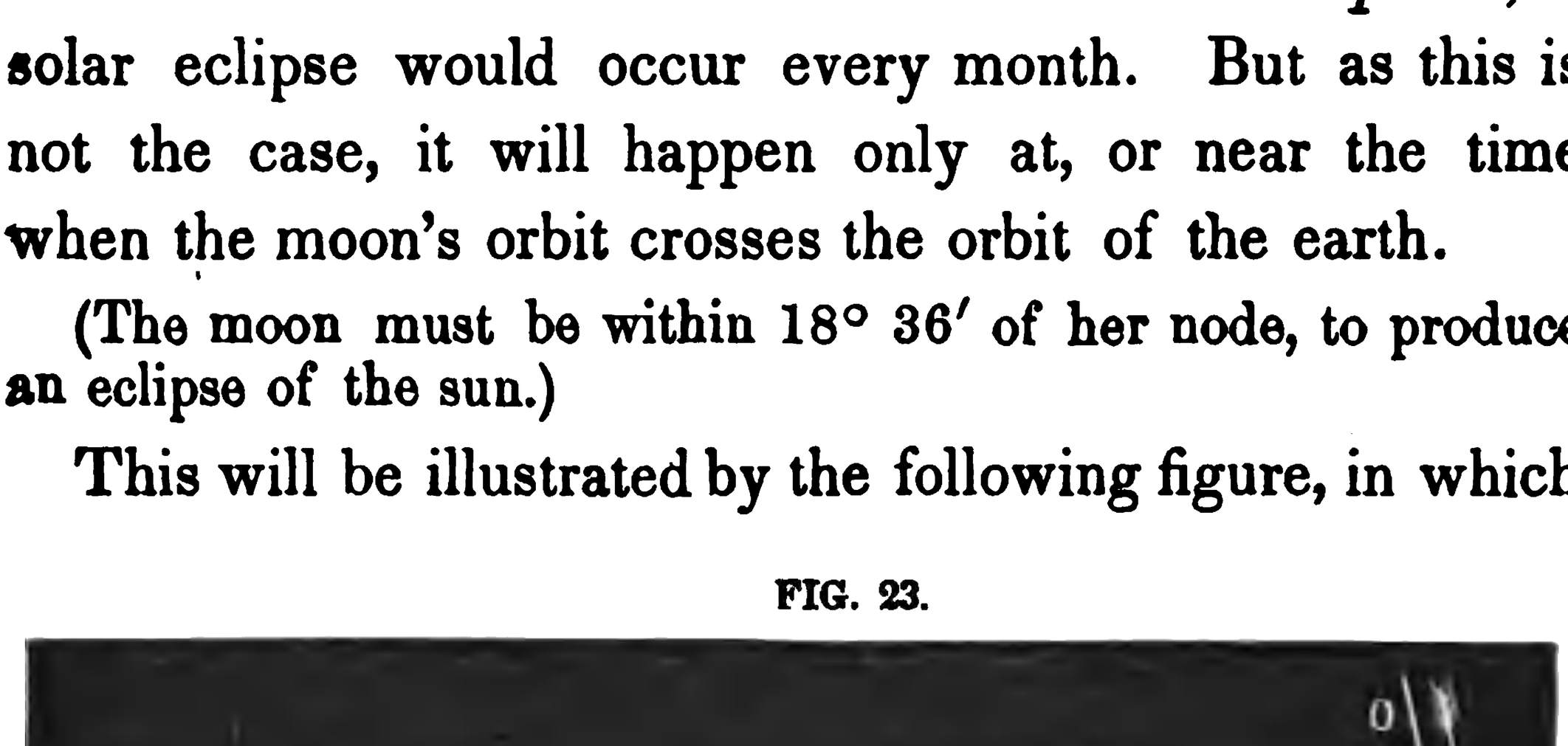
The sun can be eclipsed only at new moon, for at no other time is the moon between the earth and sun.

If the earth and sun revolved in the *same plane*, a solar eclipse would occur every month. But as this is not the case, it will happen only at, or near the time when the moon's orbit crosses the orbit of the earth.

(The moon must be within 18° 36′ of her node, to produce an eclipse of the sun.)

This will be illustrated by the following figure, in which

FIG. 23.



Z B H E, represents the earth, O R, the moon's orbit, M and M¹, two positions of the moon, and S, S¹, her *shadow*.

If the moon, when passing between the sun and earth, were at M, the sun could be seen from all parts of the earth; but if it should be at M', the observer at Z would not see the sun; hence it would be eclipsed to him.

The moon at the zenith is about 4000 miles nearer the earth, *i. e.*, nearer the observer, than when on the horizon. This difference in distance will, of course, affect the duration of an eclipse; and it may happen that a spectator at Z, in the above figure, may see an eclipse of the sun, when one at H would not. The same reason may cause an eclipse which is total at the zenith, to be *annular* if seen from the horizon.

Illustration 1. Without apparatus. Let a window represent the sun. Then the scholar, with some object, as a book, (a globe, or circular object is better,) before his eyes, can hide the window, in part, or wholly, or so as to leave a margin around the book. The idea of a solar eclipse can be very clearly conveyed by such an illustration.

Note. By allowing one scholar to carry a large globe between the class and the window, it will be easily seen why an eclipse is total at one place on the earth, while it is partial at another, for if the globe is placed directly in front, *and near* a pupil it will hide the whole window.

Illust. 2. With Tellurian. Place a small lamp on the large pulley before the sun. (*The wick of the lamp should not reach above the sun's center.*) Then turn the arm till the moon is between the earth and sun. The moon's shadow will be shown distinctly on the earth. Show that the eclipse would be total to a person in the center of the shadow,—to one at one side of the center, partial. Bend the wire on which the moon rests, and the moon will be removed further from the earth, making the shadow smaller, *i. e.*, *if the light is larger than the moon,*

and the eclipse, to an observer in the center of the shadow, would become *annular*. The obliquity of the moon's orbit is seen in the Tellurian, and at times her shadow will pass entirely above or below the earth.

Note 1. A window admitting a strong light will answer the purpose of a lamp, if the Tellurian is inclined in the direction of the light from the window.

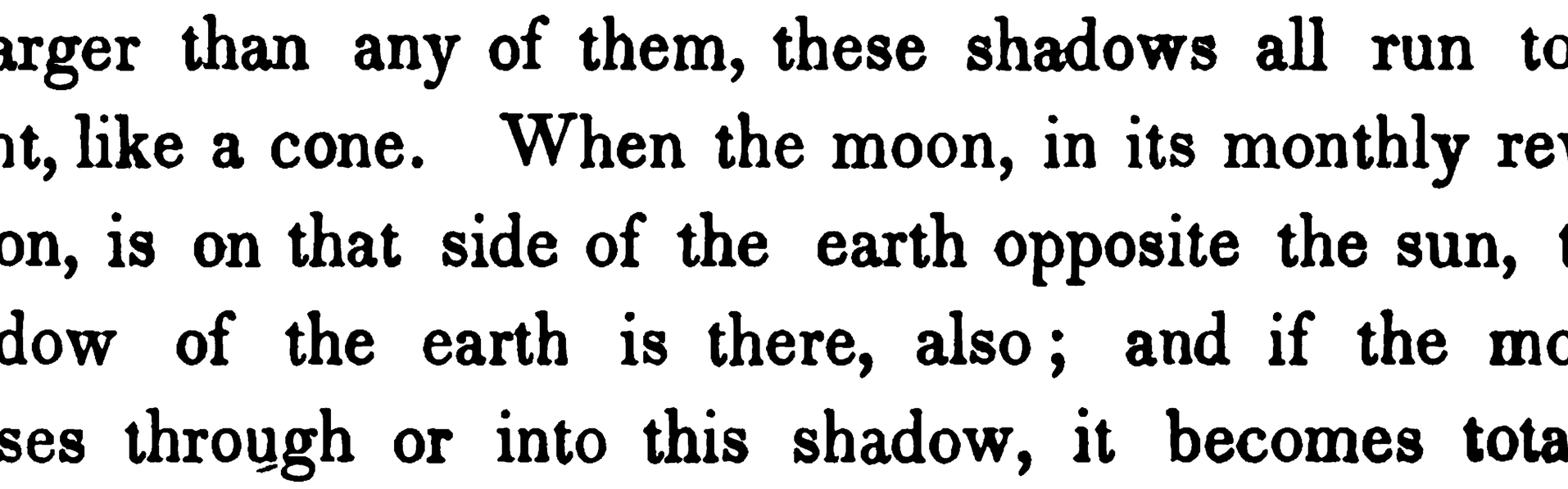
Note 2. Instead of using a light or window, the rays of the sun may be represented by a string stretched from the circumference of the sun to the earth. Let it touch the moon and observe where it reaches the earth; then do the same from the opposite side of the sun, thus representing the two outer rays of light. It will be seen that the moon will hide a part of the earth from the sun, or will hide part of the sun from the earth, *i. e.*, eclipse it. The light should be used when practicable, as it affords the *best* illustration.

ECLIPSES OF THE MOON.

The moon shines only by reflecting the light of the sun. Hence, whatever prevents the sun's light from shining upon the moon, darkens or eclipses the moon; *i. e., the shadow of this object* falls on the moon.

The sun shining on the earth, moon, and all the planets, causes each one of them to *cast a shadow*. As the sun is larger than any of them, these shadows all run to a point, like a cone. When the moon, in its monthly revolution, is on that side of the earth opposite the sun, the shadow of the earth is there, also; and if the moon passes through or into this shadow, it becomes totally or partially eclipsed.

FIG. 24.



In Fig. 24, the earth's shadow is represented by the dark space between D B, and B L. For some distance on each side of the earth's shadow, the light of *part* of the sun is intercepted, so that the moon grows gradually less bright before reaching the dark shadow of the earth; then it is eclipsed, either partially or totally, and after passing through the dark cone, must still pass through a *partially illumined* space, before receiving the full light of the sun. This space of diminished light is called the PENUMBRA, or partial shadow, and is shown in Fig. 24, on both sides of the earth's shadow, and bounded by the lines U D, D B, and B L, L W. The *path* of the moon is shown by Q M, and different positions of the moon at or near the time of an eclipse, are represented by the small circles in that path.

Illustration 1. Without apparatus. Place a mirror opposite a window, (or a solar lamp,) which shall represent the sun, and the mirror will act as the moon, reflecting the sun's rays. While the scholar looks at the window, *as seen in the mirror*, pass a large book, or frame gradually before the *real window*. To the scholar, who looks only at the reflection of the window, that reflection will be partially *eclipsed*; or if the frame be sufficiently large to cover the window, or lamp, the eclipse will be total. The *mirror* will still be seen, though the brightness of the window is hid; so the moon is seen, even in an eclipse, though deprived of its usual light; the light it receives from the earth and stars being sufficient to make its outline visible.

Illust. 2. WITH GLOBE, MIRROR, AND LAMP. *The light from a small Magic lantern, or a Police lantern is best.*

This thrown on a mirror, would be reflected brightly on a globe placed nearly between the mirror and the lantern. Move the globe till it comes between them, when it will intercept the light before it reaches the latter, thus eclipsing it wholly or in part. This illustration is most successful in a darkened room.

Illust. 3. WITH TELLURIAN. Place a light on the pulley in front of the sun, or place the instrument in the sunshine, (*the sun of the Tellurian being toward the sun in the heavens.*) As the arm is moved, the moon will be seen to come into, and pass out of the earth's shadow, as actually occurs in an eclipse. At other times the moon will pass above or below the earth's shadow, according to the elevation of the moon in its orbit.

Remark 1. If the moon revolved in the plane of the ecliptic, or the apparent path of the sun, there would be an eclipse of the moon every month. Eclipses of the moon happen only at *full* moon, for then only is she opposite the sun.

Remark 2. No more than seven eclipses can occur during one year, and when this happens, five of them will be *solar*, and two *lunar*. There will always be two eclipses of the sun in each year, but there *may* be *no* eclipse of the moon. Usually there are *four* eclipses in the year, but sometimes *six* occur.

Note. The construction of this instrument is such that the moon's orbit plane will come into the same relation to the earth's plane once in eighteen revolutions of the earth around the sun. This arrangement corresponds to the Chaldaic period, which gives the recurrence of nearly the same order of eclipses once in eighteen years and ten days. By means of this period, the ancients were enabled to foretell eclipses, but with no great degree of precision.

XXXII. TIDES.

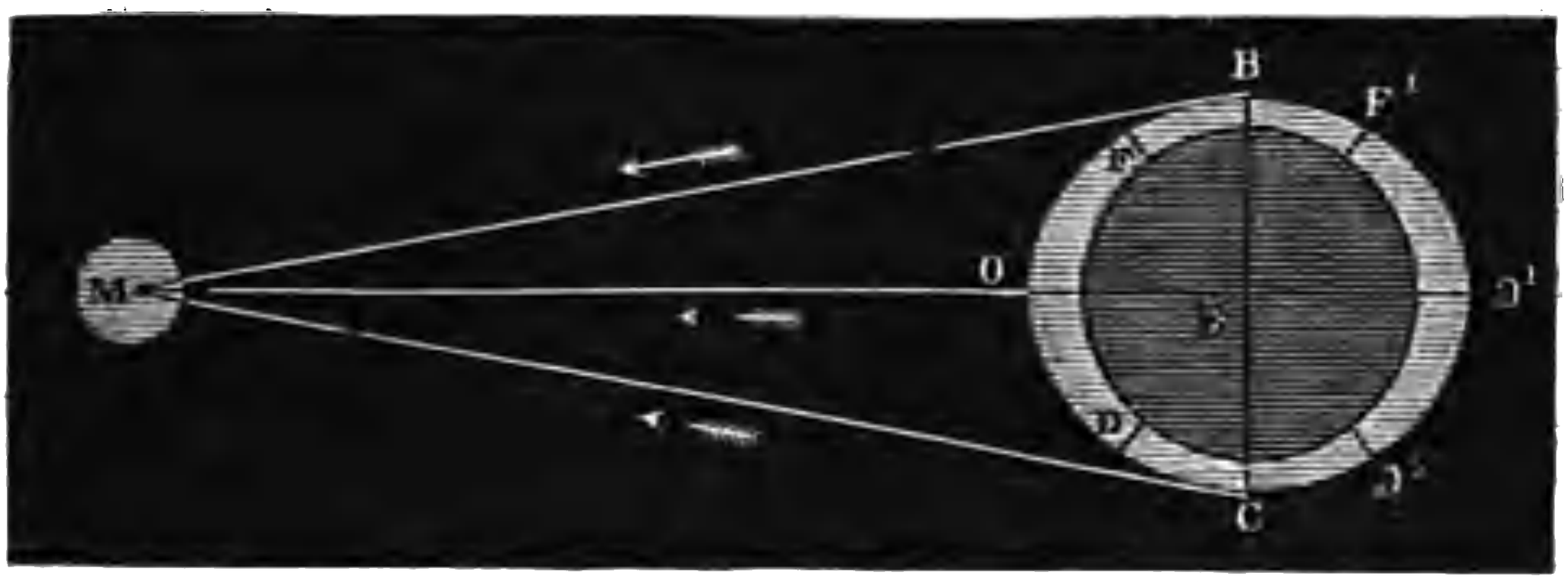
Tides are caused by the UNEQUAL attraction of the sun and moon upon different parts of the earth. They are also influenced by the form and position of coasts and harbors.

The power of attraction is inversely as the square of the distance.

The *solid* portion of the earth is attracted as if the point of attraction were at the earth's center,—the quantity of matter each side of the center being equal, and all parts being firmly united.

Hence, if the moon were at M, *Fig.* 25, the water at

FIG. 25.



O being 4000 miles nearer the moon than the center of the earth, E, will be attracted with a force as much greater than the solid earth as the square of 236,000, (distance from moon to the water,) is less than the square of 240,000, (distance from moon to earth's center;) and, the water, flowing easily, will move toward the moon faster than the solid earth. Consequently, the water will be *heaped up* under the moon, producing a high tide.

Again, the solid part of the earth will be attracted by the moon more strongly than the water on the side oppo-

site the moon, (O^1,) as the water is 4000 miles further distant; consequently, the earth will be drawn toward the moon *faster* than the water,* thus causing a high tide on the side *opposite* the moon at the same time of the high tide *under* the moon.

As the water is heaped up at these opposite points, it must necessarily be drawn away from the parts of the earth between them, thus causing a *low* tide at the places B, C, midway on each side of the earth.

Remark 1. As there are high tides at two opposite points at the same time, there will be *two* high tides on all sides of the earth in a day; also, two low tides.

Remark 2. The water, on account of inertia and friction, cannot move instantaneously; and, hence, does not quite keep up with the moon. Therefore, the time of high tides is usually two or three hours after the moon is on the meridian.

LATER DAILY RECURRENCE OF TIDES.

Tides happen about fifty minutes later every day, in consequence of the motion of the moon in its orbit around the earth.

Illustration. WITH TELLURIAN. Move the arm, thus producing revolutions of the earth and moon. Observe that any place on the earth must make *more than an entire revolution* to come around the second time under the moon; whereas, if the moon were stationary, one

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* To illustrate this, dip the finger (or a ball) in water; a drop will adhere. Raise the finger perpendicularly, with a sudden motion, and the drop will plainly be seen to grow longer; i. e., a *high tide occurs* at the end of the finger.

complete revolution would bring the same meridian again under it.

INFLUENCE OF THE SUN ON TIDES.

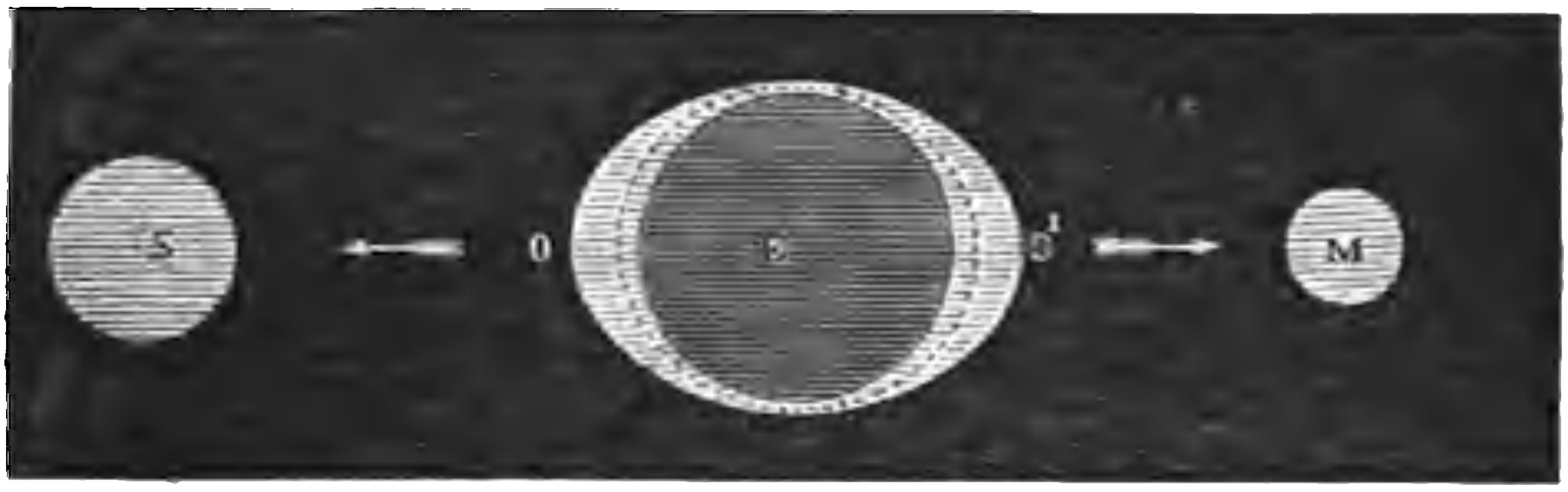
The effect of the sun's attraction is similar to that of the moon; but, from its great distance, its power is only about *one-third* that of the moon, even though it vastly exceeds the moon in bulk.

SPRING AND NEAP TIDES.

The sun and moon act independently in producing tides; and, at times, acting together, they help each other and produce uncommonly high tides called Spring tides; while, at other times each diminishes the other's influence, making the tides unusually low, or Neap Tides. The spring and neap tides occur twice every month.

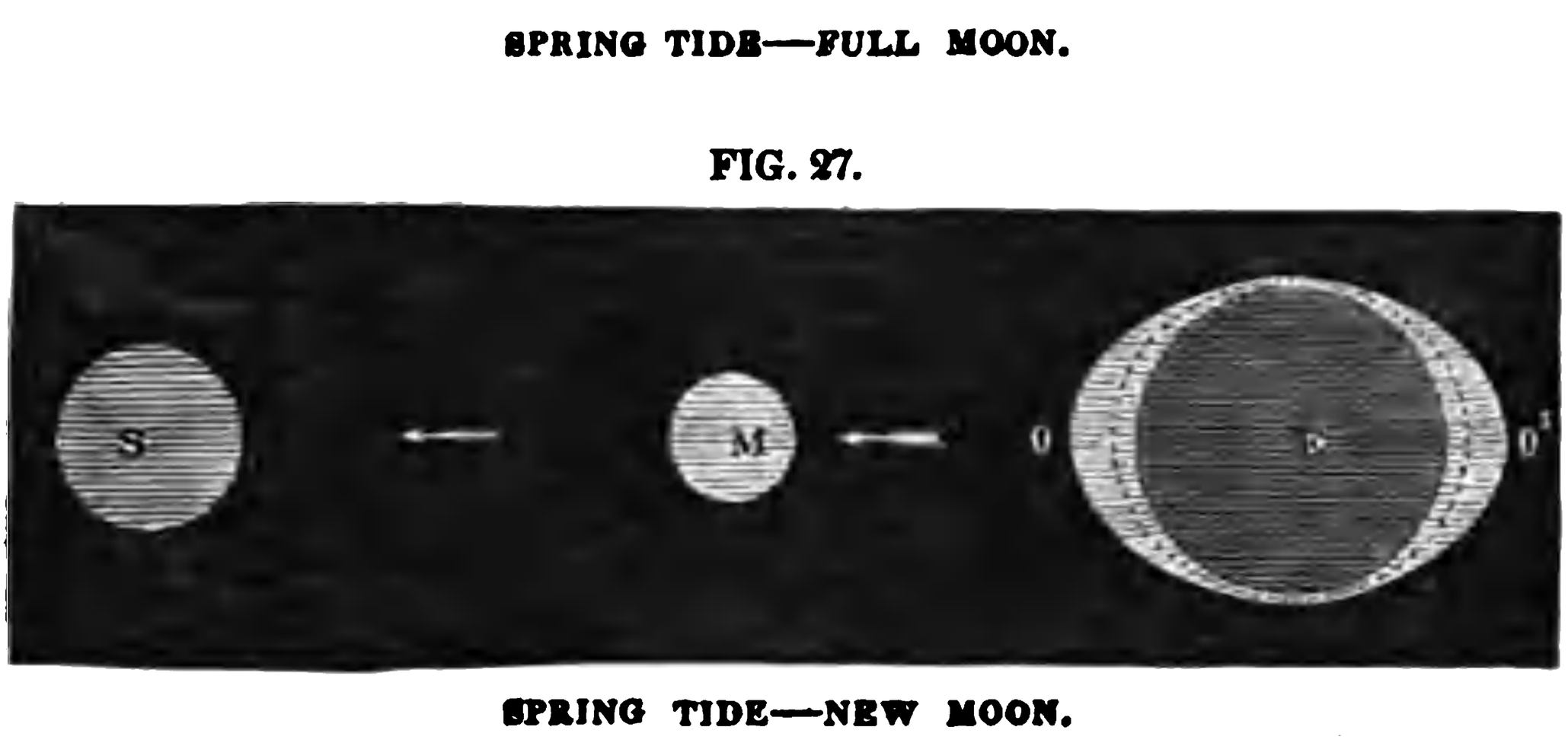
"In *Figs.* 26 and 27 the subject of the spring tides is illus-

FIG. 26.



SPRING TIDE—FULL MOON.

FIG. 27.

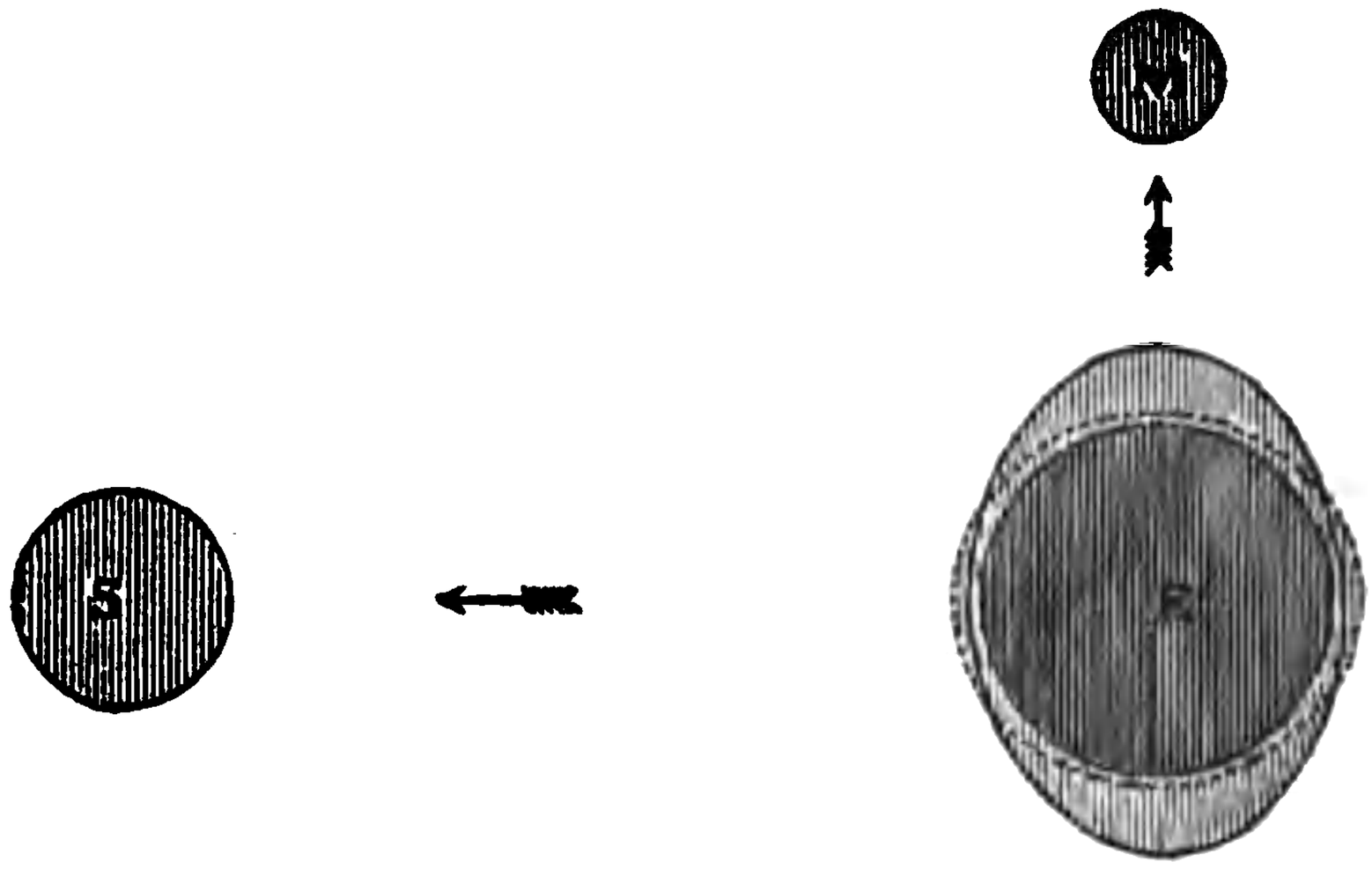


SPRING TIDE—NEW MOON.

trated. In each of these figures S represents the sun, M the moon, and E the *solid portion* of the earth. The *dotted line* inclosing the earth is the *solar tide-wave*; and, upon this, in the line of the three bodies, is heaped the *lunar tide-wave*, the boundary of which is the *outer* curved line."—(*Brocklesby's Astronomy.*)

Fig. 28 represents the positions of the sun and moon

FIG. 28.



NEAP TIDE—QUADRATURE.

in quadrature, or 90° distant from each other. In this position the sun's attraction would produce a tide as indicated by the *dotted oval line*, while the moon alone would attract the water as shown by the *outer* oval line Hence, these forces counteract each other, causing a tide much less than usual. If the attraction of the sun and moon was equal, there would be *no tide* when in this relation to each other.

HEIGHT OF TIDES.

The actual rise of water by the tide in the middle of the ocean is only two or three feet; but, by reason of the shape of the coast and other influences, it varies very much in different places. For instance, a deep bay, opening toward the ocean like a funnel, will receive a vast

volume of water at its mouth, which, being contracted by the shore, will be forced to an extraordinary height, as in the Bay of Fundy, where tides rise from 40 to 60 and even 100 feet. The tide at London rises 22 feet; at Portsmouth and Plymouth, 12.5 feet; at Liverpool, 15.5 feet; while, at Bristol, there is a tide of 33 feet.

Note. By the Tellurian, the POSITIONS of the sun and moon, relatively to the earth and to each other, can be shown distinctly; but, *no instrument* can illustrate the subject of tides so perfectly as drawings will do.

XXXIII. PRECESSION OF THE EQUINOXES.

The equinoxes are two opposite points in the heavens where the sun appears to cross the equator. (*Shown by Celestial Sphere.*) The vernal equinox is in the sign Aries, and the sun is at that point on the 21st of March. Thence it passes above the equator to the Tropic of Cancer, and returning, reaches the equator on the 23d of September, and in the sign Libra. This is the autumnal equinox. From this point the sun passes below the equator to the Tropic of Capricorn, and again returns to the vernal equinox on the 21st of the next March; being one year from the last vernal equinox.

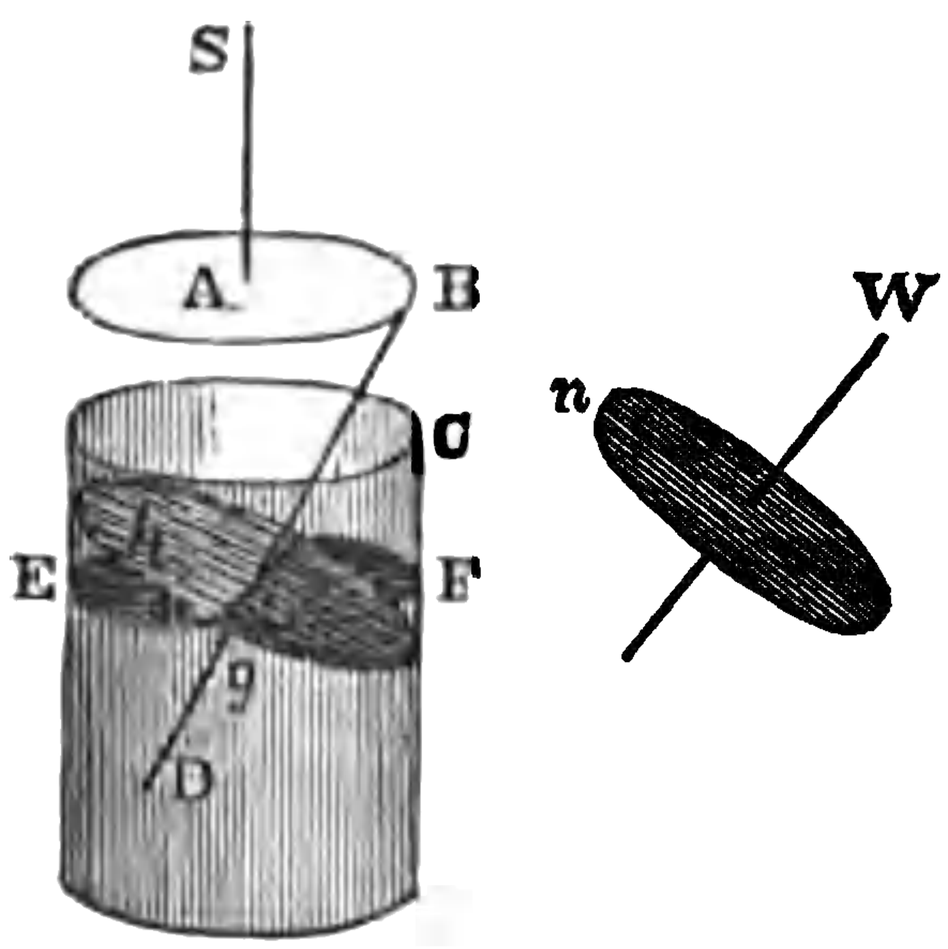
It is evident that if from one vernal equinox to another was *precisely* one sidereal year, then, at the end of ten, one hundred, one thousand or *any number* of sidereal years the vernal equinox would be in precisely the same point in the heavens; i. e., the same stars that were on the meridian at the vernal equinox in the year 1856, B.C., would be on the meridian the present year, (1856), at the vernal equinox.

But, careful observation proves that the equinoxes *do not* occur at precisely the same points.

Since the earliest maps (or registering catalogues) of the stars, the positions of the fixed stars have moved 30° east, which is equivalent to one sign in the Zodiac. Hence, it is plain, since the stars do not actually move, that the *equinoxes* have moved 30° west. The amount of this backward motion, *or precession*, of the equinoxes is found to be 50.1″ annually.

The manner in which this phenomena occurs is illustrated by the following figure, which, with the explanation, (slightly altered,) is taken from Brocklesby's Astronomy.

FIG. 29.



"Take a tumbler, (or a glass globe) D C, *Fig.* 29, partly filled with water. The *tumbler* represents the heavens, the *level surface* of the water, E F, the plane of the ecliptic, and the end, A, of the wire, S A, which hangs over the middle of the tumbler and at right angles to the water, the pole of the ecliptic. Now, procure a circle of stiff pasteboard (n,) a little smaller than the inside of the tumbler, and through its center thrust a wire, W, fixing it perpendicularly to the surface. The pasteboard represents the plane of the equator, and the wire its axis. Taking now the pasteboard by the wire we place it in the tumbler, causing half the circle to sink below the surface of the water, and half, (h,) to rise above, making an angle with the surface of the water, E F, of about twenty-three and one-half degrees.

Hemispheres, fitted to each side of the pasteboard, (n,) with the wire, W, passing through their centers, would represent the

earth. (*These are not shown in the figure.*) The pasteboard represents the plane of the equator, the surface of the water the plane of the ecliptic, the line (g,) where the pasteboard meets the water, the line of the equinoxes, and around the tumbler at the water-line, as in the heavens, the signs of the Zodiac may be supposed to be arranged, thirty degrees apart. Causing now the upper end of the wire, B, (the pole of the equator) to describe a circle* around the lower end of the wire, A, (the pole of the ecliptic,) *from east to south and west*, we shall see that the line where the pasteboard meets the water, that is the line of the equinoxes, moves also around from east to west; and, that the equinoxes, which are extremities of this line, change their position in the same direction."

If now a mark,—i. e., a meridian,—is made on the pasteboard at the point g, or equinox, and directly over it, on the tumbler, a point to designate the place of a star, and then the pasteboard revolved on the axis, the poles being unchanged, till the same point of the pasteboard intersects with the surface of the water, the two marks, to represent a meridian and a star, will exactly coincide, *as there is no precession.* But if, during the revolution on the axis, the pole, B, of the axis is moved along the south edge of the circle, A, toward A, thus changing the *direction* but not the inclination of the axis, the meridian mark on the pasteboard will be found to reach the surface of water *before coming* to the point g, on the tumbler; that is, the equinox has *gone back.*

Similar to this is the actual revolution of the earth's axis around the pole of the ecliptic; but, to perform one such revolution requires 25,791 years. Consequently, in 25,791 years the vernal equinox will occupy the exact position in the heavens it occupied this year; but, during that time, it will have moved backward entirely round the Zodiac.

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* A small circle of pasteboard may be attached to the wire at A.

POLE STAR CHANGES.

By referring to the *Fig.* 29, it is plain that the pole of the earth must point to different parts of the heavens in the course of this revolution; and, when directed toward B, it will point to a different star from the one in a line with it when directed toward A. The pole star is *any star* which is *nearest* that point of the heavens to which the pole is directed.

CAUSE OF PRECESSION OF THE EQUINOXES.

The earth is not a *perfect* sphere; but, its equatorial diameter is 26 miles longer than its polar.

It is, therefore, like a sphere to which has been *added* a ring of 13 miles thickness at the equator. As the sun would attract a perfect sphere alike in *all* positions, its influence on the earth has the same effect it would have on a *ring* 13 miles in thickness. If such a ring was inclined to the ecliptic at any angle less than 45 degrees, the force of attraction would *tend* to *draw it down* into the plane of the ecliptic. On the other hand, the rotary force would tend to keep it at its original inclination; i. e., in its original plane.

By the combined action of these two forces the ring would really be moved as if drawn by one force, acting obliquely to its plane, and would be *twisted* round from east to west, causing its axis to describe a circle round the pole of the ecliptic corresponding to the inclination of the ring, as shown in *Fig.* 29. The attraction of the sun is aided by that of the moon and planets.

Remark. The only instrument which suitably

illustrates *precession*, is the Gyroscope, or Mechanical Paradox.*

XXXIV. TRANSITS AND OCCULTATIONS.

An annular eclipse of the sun is a transit of the moon; that is, the moon passes across the sun's disk without entirely concealing it. But, as it produces a very sensible *darkening* of the sun, it is called an eclipse. When Mercury and Venus pass between the earth and sun, as they sometimes do, they appear like small and very black spots moving across the sun, but producing no sensible diminution of light. These are called *transits*. The same appearance is observable with regard to Jupiter when her moons pass between the body of that planet and the earth.

When the moons go behind the planet, or Mercury or Venus behind the sun, it is called an occultation, or hiding of the body thus concealed.

Besides the transit of Jupiter's moons they also at times eclipse her by passing between her and the sun, as the earth eclipses our moon by passing between it and the sun, and casting a shadow upon it. In such cases, the shadow thrown upon Jupiter appears like a small round and intensely black spot.

Illustration. By the Orrery, when put in motion, the transits and occultations of Mercury and Venus can be plainly shown, and, by revolving Jupiter on its axis, the

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*This instrument has recently attracted the attention of the scientific world, and is one of its greatest curiosities. For experiments and explanation, see pages 157—169.

transits, occultations, and eclipses of its moons can be represented.

The advantages to science resulting from the transits of Mercury and Venus, and from the eclipses of Jupiter's moons, are explained in treatises on Astronomy more fully than we have space for in this work. Reference will be made only to one, viz.: DETERMINING THE VELOCITY OF LIGHT, which can easily be illustrated by the Orrery.

A Danish astronomer, Roemer, being engaged in careful observation and calculation upon the eclipses of Jupiter's moons, found that when the earth was in that part of her orbit nearest Jupiter, (*show by the Orrery,*) the eclipses happened at the precise time he had calculated them; but, as the earth moved on in her orbit, the eclipses were delayed beyond his calculated time, till the earth reached the point in her orbit opposite Jupiter, when this delay was greatest. But, as she, now advancing in her orbit, approached nearer to Jupiter, the delay gradually diminished till at her nearest point, when the eclipses again exactly agreed with the calculated time.

From this he concluded that the delay arose from the longer time occupied by the light to reach him when he was further away. The difference in distance being the diameter of the earth's orbit, 190,000,000, (*show by the Orrery,*) and the difference in time of the visible and calculated eclipse being 16 minutes, he decided that it required 16 minutes for the light to go 180,000,000 miles, which would be about 192,000 miles in a single second. This is now one of the established facts of science.

LENGTH OF DEGREES OF LONGITUDE IN VARIOUS LATITUDES.

Degree of Latitude.	English Miles.	Geographical Miles.	Degree of Latitude.	English Miles.	Geographical Miles.
1	69.15	60.00	50	44.43	38.57
5	68.85	59.77	55	39.64	34.41
10	68.06	59.09	60	34.56	30.00
15	66.76	57.95	65	29.21	25.36
20	64.95	56.38	70	23.64	20.52
25	62.64	54.38	75	17.89	15.53
30	59.85	51.96	80	12.00	10.42
35	56.62	49.15	85	6.02	5.23
40	52.94	45.96	90	0.00	0.00
45	48.88	42.43			

PART III. ASTRONOMICAL.

[The following pages are designed to be illustrated by the frequent use of the Orrery.

They are also published separately, as a simple and cheap PRIMARY ASTRONOMY.]

LESSON I.

FORM AND DIVISIONS OF THE EARTH

Question 1. What is the shape of the earth?*

Answer. It is round like a ball, or a globe.

2. How large is it?

A. It is twenty-five thousand miles around, and eight thousand miles through it.

3. What do we call the distance around the earth?

A. The circumference, or the measure around.

4. What is the distance through the earth called?

A. The diameter, or measure through.

5. What is the Axis of the earth?

A. An imaginary line running through the earth from North to South.

6. Why is it called the axis?

A. Because the earth revolves round this line, as a wheel revolves on its axle, or axis.

7. What are the Poles of the earth?

A. The ends of the axis.

8. How many poles are there?

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* The teacher is referred to Sections XV. to XVII., of the "Teacher's Guide to Illustration," for modes of illustrating topics in this and subsequent lessons.

A. Two; one north and one south pole.

(The teacher should show all the following lines on the globe.)

9. What is the Equator?

A. It is a line passing around the middle of the earth, half way between the poles.

10. What are Parallels of Latitude?

A. They are lines passing round the earth from east to west, and are parallel to the equator.

11. What are Meridians?

A. They are lines round the earth from north to south, like rings, passing through the poles.

12. What are the Tropics?

A. They are two parallels of latitude, one north and one south of the equator, and each twenty-three and one half degrees from it.

LESSON II.

FORM AND DIVISIONS OF THE EARTH, CONTINUED.

13. What are polar circles?

A. Two parallels of latitude, one around the north pole, and the other around the south pole, and each twenty-three and one-half degrees from its pole.

14. Are there any marks on the *earth* like those on the globe, for equator, meridians, parallels, and tropics?

A. There are not. We suppose, or *imagine* them to be there, and therefore they are *imaginary* lines.

15. What is a Hemisphere?

A. Half a sphere.

(Show one from the Set of Solids.)

16. What is a Zone?

A. A belt or girdle round the earth.

17. What do we call the belt between the two tropics?

(Illustrate by earth of the Tellurian, or by strip of paper round the globe.)

A. The torrid belt or zone. Torrid means burning, and it is very warm in this zone.

18. There is a belt, or cap around each pole, reaching to the polar circles. What are these called?

(Illustrate as before.)

A. Frigid zones. Frigid means frozen, and water is frozen all the year in these zones.

19. Between each frigid zone and the torrid zone is another belt; what are the names of these?

A. They are called temperate zones, because they are not as cold as the frigid, nor as warm as the torrid. The one north of the equator is called the north temperate, and the other the south temperate.

20. How many zones then in all?

A. Five; one torrid, two frigid, and two temperate.

21. In which one do you live?

LESSON III.

HEAVENLY BODIES.

Question 1. What is Astronomy?

Answer. The science which treats of the heavenly bodies.

2. What do we mean by heavenly bodies?

A. The sun, moon, planets, comets, and stars, which may be seen in the sky, or heavens.

3. These have different names; but do they not all look alike?

A. They do not; the sun and moon look larger and brighter than the others.

4. Do you know any difference between the planets, comets, and stars?

A. Comets have a long bright tail, but planets and stars look alike.

Note. I will tell you one difference between them. Stars shine by their own light, like a lamp, but planets shine only by reflecting the light of the sun, just as when you hold a piece of a looking glass in the sunshine, it throws a bright spot upon the ceiling, or some other part of the room. The glass shines, and the planets shine in the same way.

5. What is a luminous body?

A. A body that shines by its own light, as a lamp.

6. What are bodies called which do not shine by their own light?

A. Opaque, or dark bodies.

7. Which of the heavenly bodies are luminous?

A. The sun, comets, and stars.

8. Which are opaque?

A. The moon and all the planets.

9. But they look so much alike, how can you tell one from the other?

A. The stars appear to twinkle, but the planets shine with a steady light, like the moon.

10. Which is the largest, the sun or moon?

A. The sun is really very much larger than the moon. The moon is so much nearer it looks as large, just as a small kite on the ground appears of the same size as a large one high in the air.

11. How many stars can you see in the sky?

A. A great many more than we can count.

Note. A telescope would show you very many more. Ask your teacher what a telescope is.

12. How many of the stars you see are planets?

A. Only six; these are Mercury, Venus, Mars, Vesta, —which is one of the asteroids—Jupiter and Saturn. They can not all be seen at the same time. But the telescope will enable us to see more than forty. Some of them are smaller, and some much larger than the earth on which we live.

Is the earth one of the heavenly bodies? Does it hang in the sky, like the stars?

LESSON IV

THE SOLAR SYSTEM.

Question 1. What is meant by the solar system?

Answer. The sun and all the heavenly bodies that move round it.

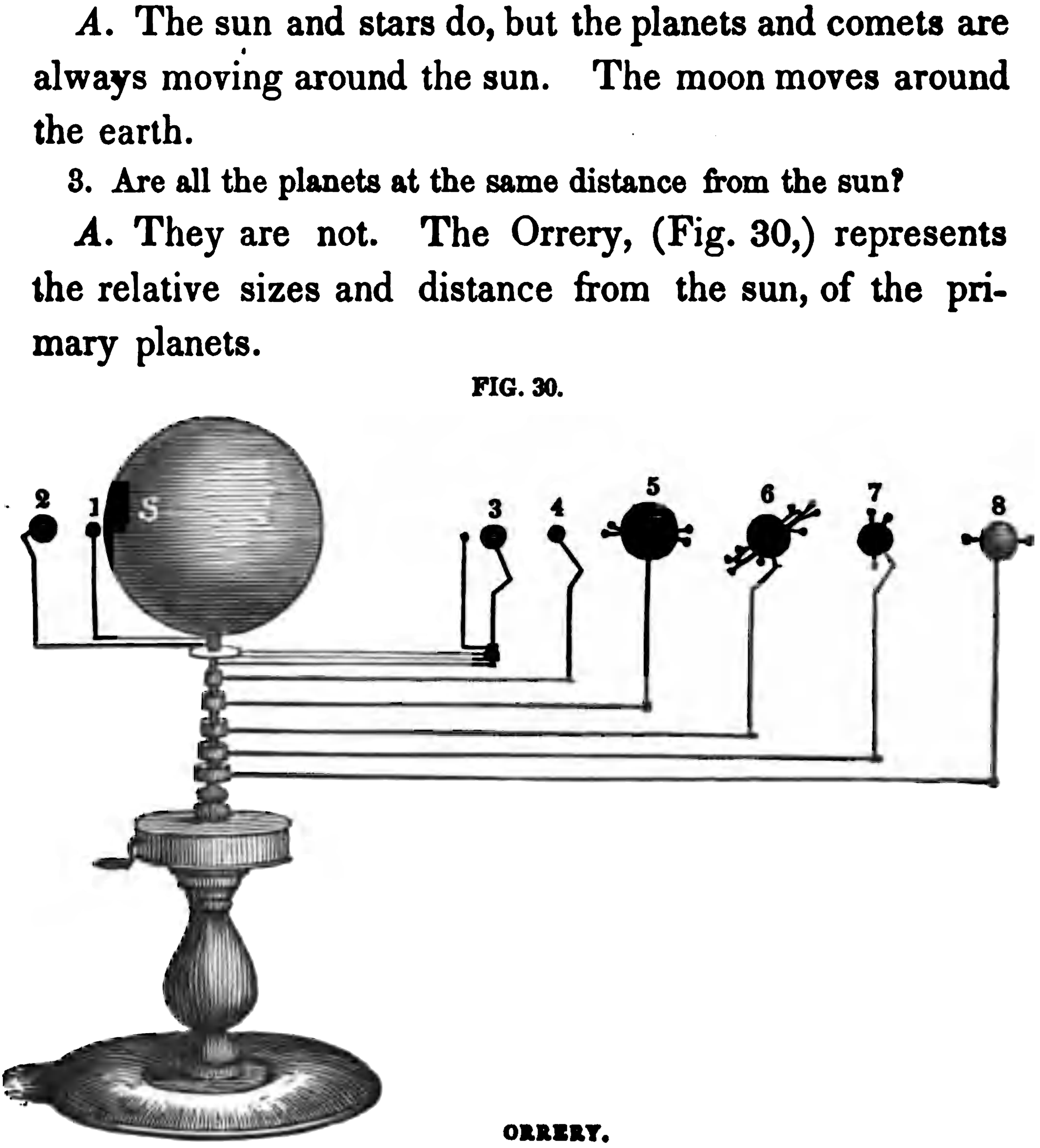
2. Do not the heavenly bodies stay in the same place all the time?

A. The sun and stars do, but the planets and comets are always moving around the sun. The moon moves around the earth.

3. Are all the planets at the same distance from the sun?

A. They are not. The Orrery, (Fig. 30,) represents the relative sizes and distance from the sun, of the primary planets.

FIG. 30.



ORRERY.

4. What are their names?

A. S, represents the sun; 1, Mercury, the nearest

planet; 2, Venus; 3, the Earth on which we are; M, the moon which moves round the earth; 4, Mars; 5, Jupiter, with four moons; 6, Saturn, with eight moons; 7, Uranus, or Herschel, with four or six moons; 8, Neptune, or Leverrier, with one or two moons.

(If we turn the crank, the planets will all move round the sun. Those nearest the sun move much faster than the others.)

5. What is meant by primary planets?

A. The planets which revolve round the sun.

6. What are secondary planets?

A. The moons, which revolve round their primaries.

7. Are there only eight primary planets, as shown by the Orrery?

A. There are between Mars and Jupiter, forty small planets, which revolve around the sun. In all there are forty-eight primary planets.

8. What are these small planets called?

A. They are called asteroids, which means "*like stars*."

9. How many secondary planets, or moons, are there?

A. Eighteen are known to exist, viz.: the earth has 1; Jupiter, 4; Saturn, 8; Uranus, 4; and Neptune, 1. Some astronomers think Uranus has 6, and Neptune 2 moons, which would make twenty-one in all.

LESSON V.

SOLAR SYSTEM, CONTINUED

1. What are inferior planets?

A. Those which revolve between the sun and earth. They are Mercury and Venus. (See Orrery.)

2. What are those called which revolve beyond the earth?

A. Superior planets. They are Mars, Jupiter, Saturn, Uranus, and Neptune. (Shown by the Orrery.)

3. What is the Ecliptic?

A. It is the path of the earth as it goes round the sun; (*shown by the Orrery;*) or as it appears to us, the sun's path in the heavens; (*shown by Celestial Sphere.*)

4. What is the Zodiac?

A. It is a belt eight degrees wide, each side of the ecliptic, making sixteen degrees wide in all, and in it are the paths of all the planets, none of which, except some of the asteroids, go more than eight degrees above or below the ecliptic. (*Shown by Celestial Sphere.*)

5. How is the Zodiac divided?

A. Into twelve equal parts called signs.

6. Can you give the names of the signs, and the day the sun enters each?

1. Spring Signs.	Aries,	sun enters	March 21st,	♈
	Taurus,	"	April 20th,	♉
	Gemini,	"	May 21st,	♊
2. Summer Signs.	Cancer,	"	June 21st,	♋
	Leo,		July 23rd,	♌
	Virgo,		Aug. 23rd,	♍
3. Autumnal Signs.	Libra,		Sep. 23rd,	♎
	Scorpio,	"	Oct. 23rd,	♏
	Sagittarius,	"	Nov .23rd,	♐
4. Winter Signs.	Capricornus,	"	Dec. 22d,	♑
	Aquarius,	"	Jan. 20th,	♒
	Pisces,	"	Feb. 18th,	♓

LESSON VI.

YEAR AND DAY.

Question 1. What is a year on the earth?

Answer. A year is the time in which the earth revolves once around the sun. It is 365¼ days.

2. Would a year be the same time on the other planets?

A. It would not. On Mercury and Venus the year is shorter, and on the other planets longer than on the earth.

3. Why?

A. Because Mercury and Venus revolve around the sun in less time than the earth, but the other planets require a longer time.

4. Can you tell the length of the year on the different planets?

A. The year of Mercury is 88 days of our time.
" " Venus is 225 " "
" " the Earth is 365¼ " "
" " Mars is 1 yr. 322 " "
" " Jupiter is 11 yrs. 317 " "
" " Saturn is 29 " 175 " "
" " Uranus is 84 " — " "
" " Neptune is 164 " 219 " "

5. What is a day on the earth?

A. It is the length of time in which the earth revolves once on its axis.

6. Do all the planets revolve on their axes?

A. They do; but some in a longer, and some in a shorter time than the earth; so their days are not the same in length as ours.

7. How long are the days of the different planets?

A. The day of Mercury is 24 hours of our time.
" " Venus is 23 " "
" " the Earth is 24 " "
" " Mars is 24
" " Jupiter is 10 " "
" " Saturn is 10½ " "
" " Uranus is unknown.
" " Neptune is "

Nota. The sun revolves on his axis in 25 1-4 days.

8. In what direction do the planets revolve on their axes?

A. From west to east; or in an opposite direction from the motion of the hands of a watch.

Nota. They move in the same direction around the sun.

FIG. 8.

SOLAR SYSTEM.

Fig. 31, on page 136 represents the relative distances of the planets from the sun, round which they revolve. In this figure the path or orbit of Neptune is represented by X; that of Uranus, or Herschel, by IX; that of Saturn, by VIII; that of Jupiter, by VII; that of the Asteroid farthest from the sun, by VI, while V represents that of the nearest Asteroid; the orbit of Mars is shown at IV; that of the Earth, at III; that of Venus, at II; that of Mercury, at I; and in the center is the sun.

LESSON VII.

DISTANCE OF PLANETS FROM THE SUN, AND RELATIVE SIZES.

Question 1. Can you tell how far each planet is from the sun?

Answer. Mercury is 37 millions of miles distant.
Venus is 69 " " "
The Earth is 95 " " "
Mars is 145 " " "
Jupiter is 495 " " "
Saturn is 900 " " "
Uranus is 1,800 " " "
Neptune is 2,800 " " "

2. How long would it take a train of cars, at thirty miles an hour, to go from the sun to Mercury?

A. One hundred and forty years, if going night and day.

3. To the Earth?

A. Three hundred and sixty-one years, or nearly four times as long as the oldest people live.

4. To Uranus?

A. Six thousand nine hundred and thirty-three years.

5. To Neptune?

A. Ten thousand six hundred and fifty years.

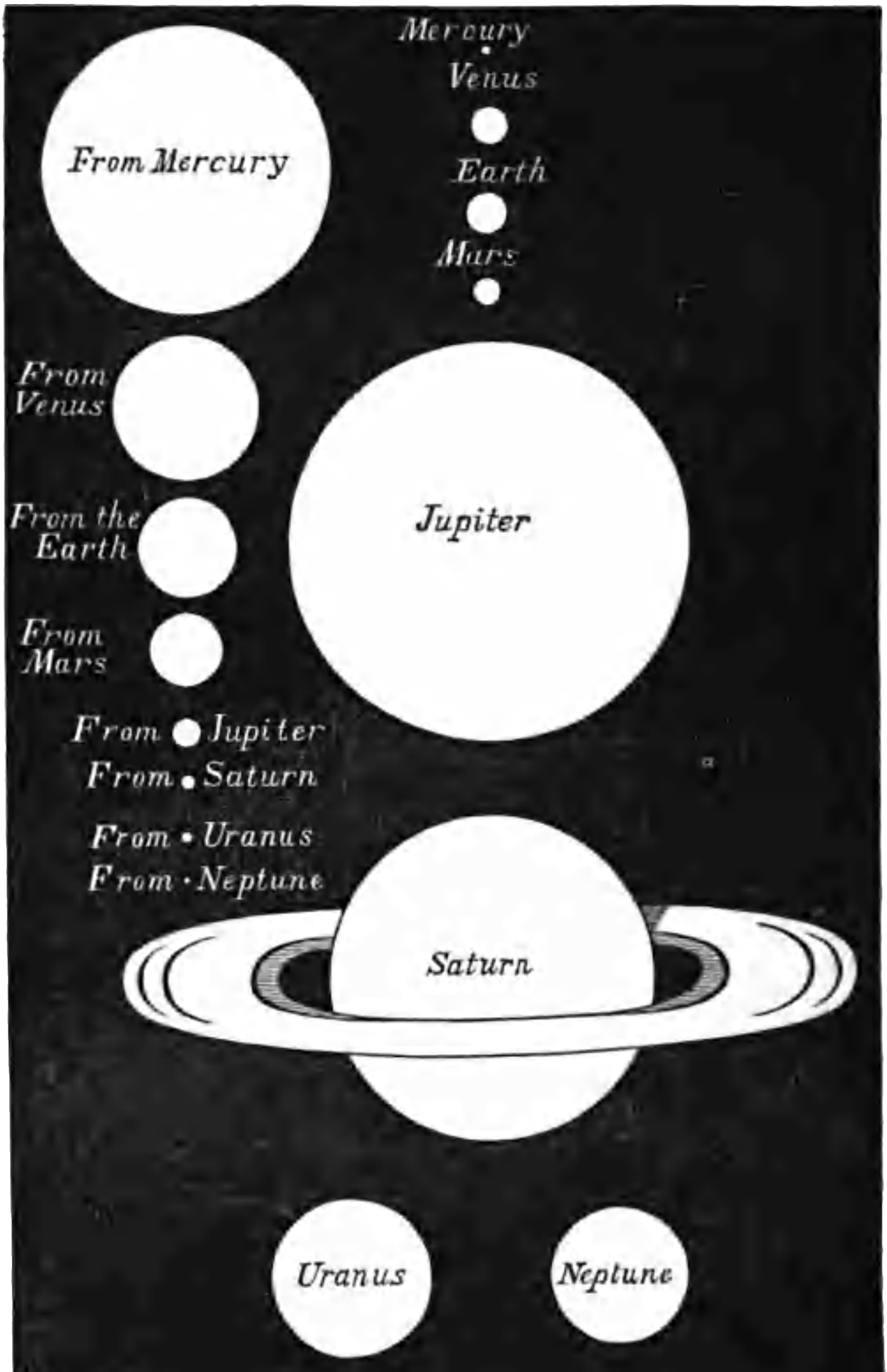
6. How would the sun look if we were at Neptune?

A. Very small, like a star; because of its great distance.

FIG. 32.

Apparent size of the Sun as viewed,

Relative sizes of the eight principal planets.



Note. In Fig. 32, at the left hand, is shown the appearance of the sun, as seen from the different planets. From Mercury it would look much larger than from the earth, and from Jupiter, Saturn, and Uranus, smaller, till from Neptune it appears like a small star.

7. How large is the earth?

A. It is eight thousand miles through it, and twenty-five thousand miles round it.

8. Is the earth larger than Mercury?

A. It is seventeen times larger.

9. How much larger than Venus?

A. Only a little larger,—about one-tenth.

10. How much larger than Mars?

A. Six times larger.

11. How much larger than Jupiter?

A. Not nearly as large. Jupiter is one thousand four hundred times larger than the earth.

12. Is Saturn larger or smaller than the earth?

A. It is one thousand times larger.

13. What size are Uranus and Neptune?

A. Nearly alike. They are ninety times as large as the earth.

Note. In Fig. 32, at the *right hand*, are shown the comparative sizes of the planets.

LESSON VIII.

FORM AND APPEARANCE OF THE PLANETS.

Question 1. Are the planets exactly round, like a sphere?

Answer. They are not, but are a little flattened at the poles.

2. Do they not look perfectly round?

A. Most of them do; but through a telescope Jupiter and Saturn are seen to be flattened at the poles, or oblate.

3. How much greater is the diameter of Jupiter and Saturn at the equator than at the poles?

A. The equatorial diameter of Jupiter is 6,000 miles greater than its polar; that of Saturn, 7,500 miles greater.

4. How much greater is the equatorial diameter of the earth than its polar?

A. Only 26 miles.

5. How do the planets appear to the eye?

A. 1. Mercury looks like a star, and is a ways near the sun. Its color is a slight blue.

A. 2. Venus is of a silvery white color, and when at a distance from the sun, is our bright and beautiful morning or evening star.

A. 3. Mars appears like a bright red star.

A. 4. Jupiter and Saturn are large, bright stars.

6. How do they look through a telescope?

A. 1. Mercury appears round, like the moon, and has numerous spots on it, which are supposed to be plains, valleys, mountains, volcanoes, &c.

A. 2. Venus looks like a beautiful white, and very brilliant moon, and is also covered with spots. Some of her mountains are thought to be over twenty miles high.

A. 3. Mars looks like a small, red, *full* moon with spots.

A. 4. Jupiter resembles the full moon, but is oblate in shape. It has no spots, but appears to have several irregular dark stripes, or belts across it. It has also *four* moons revolving round it, which look like small stars.

A. 5. Saturn also looks like an oblate full moon, of a lead color, and has *eight* little moons of its own. It has, besides, two* beautiful white rings around it, one inside of the other.

(Represented by the Orrery.)

---

* The *two* rings are now discovered to be *five*. Two of them are dark and three bright.

7. Do the rings move?

A. They revolve around Saturn once in 10¼ hours, or as often as it revolves on its axis, *and* in the same direction.

8. How would the rings look to persons upon Saturn?

A. Like broad belts of light in the sky, shining like the full moon. The two rings are about thirteen times as wide as our moon.

9. How do Uranus and Neptune appear through the telescope?

A. Like small globes, of an ash color.

10. Have they no moons, rings, belts, or spots?

A. Uranus has six moons and Neptune one or two, but these planets are so distant the moons cannot easily be seen without a powerful telescope. No rings, belts or spots have been discovered on them.

LESSON IX.

LIGHT, HEAT, AND SEASONS OF THE PLANETS.

Question 1. How many seasons have we on the earth?

Answer. Four: Spring, Summer, Autumn, and Winter.

2. How long are they?

A. Each are three months, or 91 days in length.

3. Can you tell what seasons Mercury has, and how much light and heat from the sun?

A. Mercury has about six times as much light and heat as the Earth, but her seasons are unknown.

4. How warm would that make Mercury?

A. Very hot. Much hotter than boiling water, (325°.)

5. Can there be any water there, or any people like us?

6. How would it seem if you were at Venus?

A. It would be twice as warm and twice as light as here.

7. At Mars?

A. There would be only half as much light and heat.

The seasons would be like ours, but longer, having 172 days each.

8. At Jupiter?

A. Jupiter has nearly the same season all the year, and only one-twenty-seventh as much light and heat as we.

9. At Saturn?

A. Saturn has one-ninetieth as much light and heat. There are four seasons like ours, only each one is seven and one-half *years* long, for Saturn's year is thirty of our years.

10. Will not so many moons and rings make the evening very pleasant on Jupiter and Saturn?

A. They will make them much lighter than one moon would; but, these moons do not give as much light as our moon.

11. Can you tell about the light at Uranus and Neptune?

A. They are so very far off they can have but very little light and heat, for the sun will be to them like a star. (See *Fig*. 32.)

LESSON X.

THE SKY, AND WHAT KEEPS THE PLANETS IN IT.

Question 1. What does the sky seem to be?

Answer. A blue arch over our heads, in which are the sun, moon, and stars.

2. Do you know what people about 400 years ago thought it was?

A. They thought it was made of eight crystal (glass like) arches, one inside of the other. They thought the sun, moon, and stars were in these different arches, and were held up by them; and, that the arches were crystal, so the stars could shine through them.

3. Where did they think the Earth was?

A. In the center of these arches Some thought it was held up by an elephant or a monstrous serpent.

4. If we were in a room so large that we could not see the sides of it, and so high we could not see the top, how would it seem to us?

A. Like an arch; for we could see just as far in all directions.*

5. Is there, then, *nothing* where the sky and stars seem to be?

A. There is nothing, or at most, only a substance somewhat like air, but very much lighter.

6. Then what keeps the stars from falling?

A. God keeps them in the sky.

(Yes, we know that; but, doesn't any one know *how* he keeps them?)

7. In explaining this, we must ask some more questions. If you hold a needle in the air by a string, and then cut the string, where would the needle go?

A. It would fall to the earth, because the earth draws it.

8. If, just as you cut the string, you hold a strong magnet near the needle, what will happen?

(Illustrate by use of magnet.)

A. The needle will go to the magnet, because that draws it more powerfully than the earth does.

9. If the stars should drop from the sky, would they fall to the earth?

A. They would not; but, would go to the sun, because that draws (or attracts) them more than the earth does.

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* The teacher may illustrate this by using a pair of dividers. Place one foot where the person stands, and let the other represent the distance the eye can see. As we can see equally far in all directions, a semi-circle described above the place where the person stands will represent the sky.

LESSON XI.

WHAT KEEPS THE STARS IN THE SKY.

Question 1. If you tie an India rubber cord to a bullet, and, holding one end of the cord, pull the bullet away, and then let it go, what will it do?

A. It will be drawn back again toward the hand.

2. But, if you swing it swiftly round, like a sling, what will happen?

A. The bullet will try to fly away, and will stretch the cord as if some one pulled it away; and, the faster it is swung, the harder it will pull to get away.

3. If you let the string go, when it is swinging round very fast, what will happen?

A. The bullet will fly off in the air.

4. What do we call the power which makes it fly away from the hand?

A. Centrifugal force, or the force which makes it fly *from the center.*

5. What do we call the power of the India rubber cord, which draws it toward the hand?

A. Centripetal force, or the force which brings it *to the center.*

6. If you could swing it just fast enough, so the centrifugal force should be exactly as strong as the centripetal, what would happen?

A. It would go round and round, and neither go further off nor come nearer to the center.

7. What if the centrifugal force was stronger than the centripetal?

A. The bullet would go further and further off, stretching the cord more and more.

8. What if the centripetal force were the stronger?

A. The cord would grow shorter, and draw the bullet nearer to the hand.

9. The planets all revolve round the sun, like the bullet round your hand. What force will that give them?

A. The centrifugal force; and, they will all try to fly away from the sun.

10. The sun draws or attracts them all, as a magnet draws a needle. Will not such a drawing be just as good as if it was done by an India rubber cord?

A. It will, and will pull the planets toward the sun.

11. What force will this be?

A. The centripetal force.

12. If these two forces (centrifugal and centripetal) of the planets exactly balance, what will the planets do?

A. They will keep revolving round the sun.

13. Can they ever fall to it, or fly away from it?

A. They cannot; and so they will always stay in the sky.

14. Has God made these two forces to balance each other?

A. He has; and, this is *how* he keeps the planets from falling.

15. Are *all* the stars kept in the same way?

A. We suppose they are; but, all, except the planets and comets, are so very far off we cannot see that they revolve, even with the largest telescopes.

LESSON XII.

THE EARTH A STAR.

Question 1. Does the Earth look like a star?

Answer. It does not.

2. Would it look like one to us if we lived on Mars or Jupiter?

A. It would, for it is a star as much as either Mars or Jupiter is.

3. Would the other planets look like the earth if we could go to them?

A. They would, in many respects. They have rocks,

mountains, and valleys; but, some are much colder while others are very much warmer than the earth, because they are nearer to the sun.

4. Is it not very pleasant on Jupiter, Saturn, and Uranus in the evening on account of so many moons?

A. It must be so, for some of their moons will shine every night; but, they are so far from the sun, that six or eight moons will give no more light there than our one does to us.

5. Does the earth remain still in the sky?

A. It does not; but turns over every day

6. Does it keep in the same place all the time?

A. It does not; but moves very swiftly in its journey around the sun.

7. How fast does it move?

A. Every minute it moves a thousand miles; which is further than a rail-road car would go in a day and a night.

8. Do all the planets move as fast?

A. Mercury, which is nearest the sun, goes much faster, those which are farthest from the sun much slower.

9. What would happen if the earth should go slower than it does?

A. It would fall to the sun.

10. What if it were made to go faster?

A. It would fly away among the other stars. God has made it go just fast enough to have the centrifugal force exactly balance the centripetal, and the earth goes round the sun every year in the same path.

LESSON XIII.

THE MOON.

Question 1. Is the Moon a star?

Answer. It is such a star as the planets are; for, it shines by reflecting the light of the sun, as they do.

2. Why does it look so much larger than they?

A. Because it is very much nearer to us.

3. How large is it?

A. It is 2,180 miles in diameter, which is smaller than Mercury, and 49 times less than the earth. It would take seventy millions of moons to make a body as large as the sun.

4. But, the moon looks as large as the sun?

A. The sun is 400 times as wide as the moon, and the moon is 400 times as near us as the sun, so that they appear to be nearly of the same size.

5. How long is the moon's year?

A. About one month.

(The moon's year is the time it requires to perform one revolution *round the earth*.)

6. How long is its day?

A. One month. The moon has only one day in her year.

7. What is new moon?

A. It is the moon when we first begin to see it, like a crescent, and always in the west soon after sunset.

8. What is the moon's First Quarter?

A. It is when it has gone one quarter round the earth; and, it is then a half moon.

9. What is Full Moon?

A. It is when the moon appears entirely round. It is then half-way round the earth, and rises in the east when the sun sets.

10. When the moon has passed *Three Quarters* round the earth, how does it look?

A. It is a half moon again, having grown smaller every day since the full moon.

11. What is the Old Moon?

A. It is the moon after passing the Third Quarter. It

grows continually smaller till it is again a crescent, and finally disappears entirely.

12. How does the old moon differ from the new moon?

A. The horns, or points, of the new moon point east, and those of the old moon west.

LESSON XIV.

THE MOON, CONTINUED.

Question 1. Does the full moon look perfectly bright all over its surface?

A. It does not. Dark lines and spots are seen on it.

2. What is it that is called "the Man in the Moon?"

A. It is a large mass of dark lines looking something like a man's head.

3. What are these dark spots?

A. They are mountains or valleys on the moon?

4. How is this known?

A. By looking at the moon through very large telescopes.

5. How does the moon look through a telescope?

A. Much larger, and we see every thing on it more plainly.

(*Fig.* 33 represents the moon at first quarter as seen by the telescope.)

6. Are the mountains in the moon high?

A. They are. Many of them appear to be as high as the highest on the earth. They are also very numerous, and some are thought to be volcanoes.

7. Is there water on the moon?

A. It is supposed not, for the long hot days would evaporate it all, and then it would form clouds around the moon, which are never seen.

FIG. 33.

TELESCOPIC APPEARANCE OF THE MOON IN QUADRATURE.

8. Was it not once thought there were oceans on the moon, as there are on the earth?

A. It was; but larger telescopes show that those are plains or prairies instead of oceans.

9. How far is the moon from the earth?

A. 240,000 miles; but this is much nearer than any other planet.

10. How many motions has the moon?

A. Three. It revolves on its own axis; and, at the same time, revolves round the earth, and also goes with the earth round the sun.

LESSON XV.

ECLIPSES.

Question 1. What is an eclipse?

A. It is the hiding or darkening of part or the whole of the sun or moon.

2. When the sun is eclipsed, what is it called?

A. A SOLAR eclipse.

3. What is an eclipse of the moon called?

A. A LUNAR eclipse.

4. When the sun or moon is entirely hid, what do we say it is?

A. A TOTAL eclipse.

5. When only part is hid?

A. A PARTIAL eclipse.

6. What causes a solar eclipse?

A. The moon passes between the sun and earth, and hides the sun from us.

7. What causes a lunar eclipse?

A. The earth comes between the sun and moon, and the shadow of the earth falls on the moon, making it dark, so that it cannot shine.

8. Does a lunar eclipse hide the moon?

A. *It does* not; but, only stops the sun from shining on it.

9. Why are solar eclipses nearly always partial?

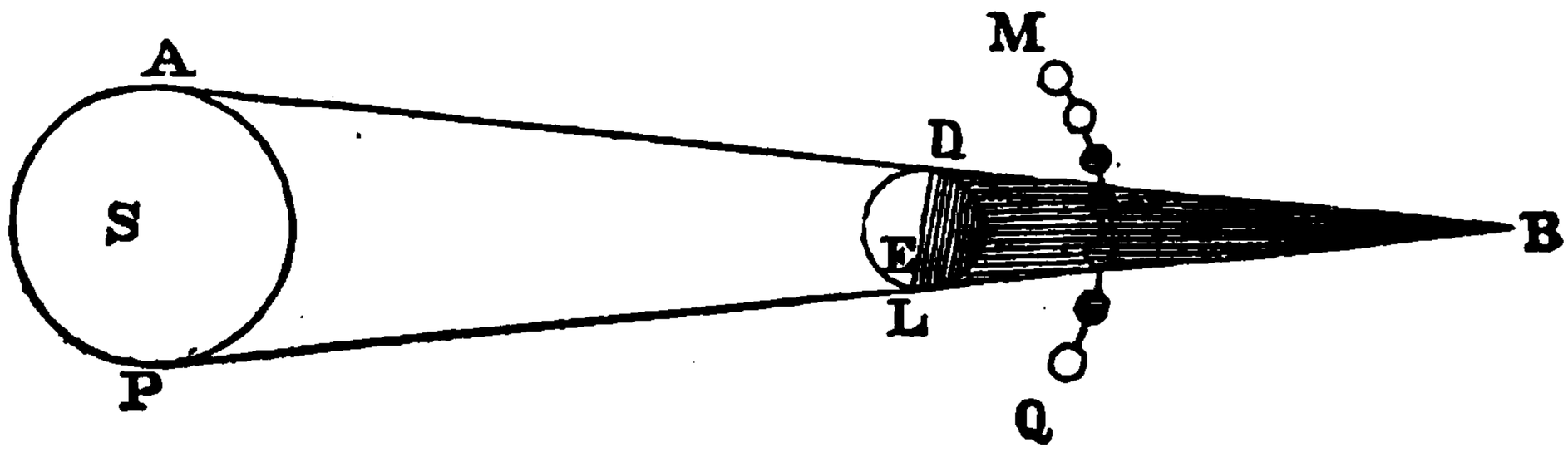
A. Because the moon is so small it cannot hide the whole of the sun, except when it is nearest to the earth.

(Illustrate by Tellurian, and see Part II., Eclipses.)

10. Why are lunar eclipses often total?

A. Because the earth is larger than the moon, and its shadow sometimes covers the moon entirely.

FIG. 34.



(In *Fig.* 34 the dark shadow of the earth comes to a point at B, and the moon, M, is seen completely covered by it; in fact, it would be covered if it was twice as large.)

11. Why are not the lunar eclipses *always* total?

A. Because the moon is sometimes partly above or below the earth's shadow, so that only part of the moon is darkened.

Note. The moon sometimes is entirely above or below the earth's shadow when the earth comes between it and the sun, and then there is no eclipse.

12. What is an ANNULAR eclipse?

A. It is when the moon eclipses the center of the sun, but is too far off to hide it all, and the edge of the sun is seen around the moon like a shining ring. ANNULAR means *like a ring*.

13. How many eclipses can there be in a year?

A. The greatest number is seven: five of the sun, and two of the moon.

14. What is the least number possible?

A. Two: both of the sun.

LESSON XVI.

COMETS.

Question 1. What are comets?

A. They are bodies moving around the sun, and noticeable for their long trains of light, or tails.

2. Why do we not see them every night?

A. They come very near to the sun and then go off an immense distance, far beyond the reach of the largest telescope. When they are near the sun, we can see them every evening.

(Two comets and their paths are shown in *Fig.* 31. It will be seen that their orbits are not circles.)

3. Do they move swiftly?

A. When near the sun, they move very rapidly; but, as they go further from it, they move more slowly. Some have been known to move about one million miles an hour.

4. Are comets solid like the planets?

A. They are not; but, appear like fog or vapor. It is supposed they are gas, like our atmosphere.

5. Do they shine by their own light?

A. They shine by reflecting the light of the sun, as the planets do.

6. How many comets are there?

A. This is not known. About five hundred have been seen.

7. Do these all have tails?

A. They do not. Some have several, others one, and some none at all.

8. Are they often seen?

A. Some are seen every few years; but some of the

largest are out of sight fifty to seventy years at a time. One comet is gone 570 years.

9. Do the comets go as far off as the stars are?

A. They go far beyond the planets, but not as far as to the stars. Only the eye of God can trace them in these long journeys.

10. How were comets regarded a few hundred years ago?

A. People were very much afraid of them, for they supposed God sent them to foretell famine, war, pestilence, or other great evils that should befall the nations.

LESSON XVII.

FIXED STARS.

Question 1. The planets are found to move around the sun, and are sometimes nearer and sometimes farther from each other. Do the stars move in the same way?

Answer. They do not appear to; and hence, they are called fixed stars.

2. Do they shine by their own light?

A. They do; and are believed to be suns like our sun.

3. Are they as large as our sun?

A. Some are not; others are larger; but, from their immense distance, we know but little of them.

4. How far are they from us?

A. The nearest fixed star is so far away that a cannon ball, going 500 miles an hour, would go four millions of years before reaching it.

(If such a cannon ball had been fired when Adam was created, it would now be only about *one thousandth part* of the way to the nearest fixed star.)

5. Do these suns or fixed stars have planets revolving round them as our sun does?

A. It is probable they do; but, the distance is so great, the planets cannot be seen.

6. Are there, then, other worlds than ours?

A. There are. Every planet is another world, whether it revolves around our sun or some other.

7. Are there people living on them?

A. We do not know that other worlds are inhabited; that only God can tell.

LESSON XVIII.

NEBULÆ.

Question 1. What are Nebulæ?

Answer. They are clusters of stars, so far distant that they appear like little spots of thin white cloud. (NEBULÆ *means clouds*.)

2. How do the nebulæ appear through a telescope?

A. Some are shown to be clusters of stars; others look like spots of cloud, even through the most powerful telescopes.

3. Are the nebulæ connected with the solar system?

A. They are not: they are very far beyond the farthest fixed stars. It is believed that our solar system, and all the stars we can see, form one nebula.

4. Can any of the nebulæ be seen with the naked eye?

A. One, in the constellation Orion, is visible.

(Ask your teacher to point it out.)

What is called the "Milky Way" is one of these nebulæ, and the only one belonging to our cluster or nebula.

5. How many nebulæ are there?

A. No one can tell. There may be as many *clusters* as there are stars in our cluster. About 6,000 have been already discovered.

6. And, do these nebulæ each have suns, moons, planets, and stars, like ours in them?

A. We know some have suns (or stars;) and, it is

probable they have, also, moons and planets. Our own sun, moon, planets, and stars, all together would appear to be only a small white cloud-like spot if seen from one of those nebulæ.

7. If we could go far beyond the most distant fixed star, and could have power to see all the Universe, how would it appear?

A. We should probably see the heavens filled with clusters of stars. Some of them, nearest to us would be seen to have suns, moons, planets, and thousands of stars. Others, more distant, would show only a few bright stars in the midst of a haze, like the Milky Way; and, still, others would be like spots of cloud, as the nebulæ now look to us.

8. Can God see them all at once?

A. He can; for, God is everywhere. He made them all, and keeps them.

"He telleth the number of the stars: he calleth them all by their names."—*Psalm* CXLVII, 4.

9. What do the stars teach us of God?

A. His greatness, wisdom, and power.

"The heavens declare the glory of God, and the firmament showeth his handiwork.

"Day unto day uttereth speech, and night unto night showeth knowledge.

"There is no speech nor language where their voice is not heard."—*Psalm* XIX, 1–3.

"Lo, these are parts of his ways; but how little a portion is heard of him."—*Job*, XXVI, 14.

LESSON XIX.

THE ATMOSPHERE

Question 1. What is the atmosphere?

Answer. It is the air we breathe. It surrounds the earth like an ocean forty-five miles deep. Birds *swim in the air ocean*, as fish swim in the ocean of water

2. How will it affect us to go up in the air two or three miles in a balloon?

A. We should find it very cold, and the air would be so much lighter, that it would be difficult to breathe.

3. What is wind?

A. It is only the air moving. Sometimes we can hardly feel it; but, at other times, it can lift us up, and even pull up trees and take off roofs of houses.

4. How fast does the air move?

A. A *gentle breeze* moves about six miles an hour, or, as fast as a horse trots. A *high wind* moves thirty or forty miles an hour, or, as fast as rail-road cars.

A *hurricane* moves eighty or a hundred miles an hour.

5. What makes wind?

A. Air, when heated, rises, and the cold air rushes in to fill its place, causing *wind*.

6. What are clouds?

A. They are collections of steam, or vapor, in the air.

7. How high above the earth are they?

A. Sometimes two or three miles high; at other times not more than half a mile. Sometimes they touch the earth, and are then called fog.

8. What is rain?

A. When the fog of the clouds collects into drops and falls we call it rain.

9. What is hail?

A. It is the drops of rain frozen as they fall.

10. What is snow?

A. When the vapor of the clouds is frozen, before it collects into drops, it falls in the form of snow.

"Stand still and consider the wondrous works of God." * * * "For he saith to the snow, Be thou on the earth; likewise to the small rain, and to the great rain of his strength."—*Job*, xxxvii. 14, 6.

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The Teachers' Home,

Conducted at New York, by F. C. BROWNELL, and at Chicago, GEORGE SHERWOOD, takes this department of labor, proposing to ca out such a plan; and we cordially welcome it as an educational pow and commend it, and its conductors, to the confidence and general p onage of Teachers and School Officers in the several states, believi that their generous sympathy and co-operation in this enterprise, w promote the true interests of education.

APRIL 20, 1859.

NEWTON BATEMAN,
State Superintendent of Public Instruction of Illinois.

HENRY BARNARD,
Chancellor of the University of Wisconsin.

J. W. BULKLEY,
Superintendent of Public Schools of Brooklyn, N, Y.

GEO. N. BIGELOW,
Principal of Framingham State Normal School,

DAVID N. CAMP,
Superintendent of Common Schools of Connecticut.

D. H. COCHRAN,
Principal of N. Y. State Normal School.

LYMAN C. DRAPER,
Superintendent of Public Instruction of Wisconsin.

MARSHALL CONANT,
Principal of State Normal School, Bridgewater, M

MARK H. DUNNELL,
Superintendent of Common Schools of Maine.

ALPHEUS CROSBY,
Principal of State Normal School, Salem, Mass.

HENRY C. HICKOK,
Superintendent of Common Schools of Pennsylvania.

RICHARD EDWARDS,
Principal of St. Loüis Normal School, Missouri.

JOHN D. MATTHEWS,
Superintendent of Public Instruction of Kentucky.

C. E. HOVEY,
Principal of Illinois State Normal School.

IRA MAYHEW,
Eight years Superintendent of Education in Michigan.

WM F. PHELPS,
Principal of New Jersey State Normal School.

JOHN D. PHILBRICK,
Superintendent of Public Schools of Boston.

ANSON SMYTH,
State School Commissioner of Ohio.

WM. H. WELLS,
Superintendent of Public Schools of Chicago, Illinois.

J. P. WICKERSHAM,
Principal of Lancaster Co. Normal School, Penn.

J. S. ADAMS,
Secretary of Vermont Board of Education.

C. H. WILEY,
Superintendent of Common Schools, N. Carolina.

J. M. GREGORY,
Superintendent of Public Instruction of Michigan.

SAMUEL L. RUGG,
Superintendent of Public Instruction of Indiana.

THOMAS H. BURROWES,
Superintendent of Schools in Pennsylvania.

D. FRANKLIN WELLS,
Principal of Normal Dept., Iowa State Univ

J. N. DICKINSON,